# Stable Isotope Analysis of a Middle Woodland Population from North Central Kansas

By



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Submitted to the graduate degree program in the Department of Anthropology and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Master of Arts.

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## Abstract

This study sought to examine the paleodiet and temporality of a Middle Woodland group from five sites in north central Kansas. This goal was accomplished by submitting 21 samples for stable isotope ratios analysis (SIRA) and 12 samples for bone collagen AMS radiocarbon dating. Results of AMS radiocarbon dating indicated a temporal range of cal. 349 B.C. to A.D. 376. Results of SIRA indicated mixed dietary patterns. Through visual assessment and statistical analyses, it was determined that their dietary patterns formed two clusters. Cluster 1 was defined by low stable carbon and nitrogen values and Cluster 2 was defined by high stable carbon and nitrogen values. Results were interpreted in terms of flora and fauna from the archaeological record of nearby contemporaneous sites. Other causal factors for stable isotope distribution were taken into account, including paleopathology, sex and age, time, social stratification, and multiple group usage. Based on the evidence available, it was determined that stable isotope ratio distribution was caused by limited nutritional stress, and a varied consumption of fauna and flora.

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# Chapter One:

# Introduction

The use of stable isotope ratio analysis (SIRA) for paleodietary reconstruction in archaeology is a recent innovation. Until the late 1970s, archaeologists relied mainly on ethnoarchaeological studies, tooth wear, and faunal and botanical remains to reconstruct individual diet. Steps toward the use of SIRA for this purpose began in 1964, when P.L. Parker suggested that stable carbon isotopes could be used as dietary tracers. Parker's (1964) proposed this usage based on the recent discoveries of plant photosynthetic pathways, $C_3$, $C_4$, and CAM (Calvin and Benson 1948; Hatch and Slack 1966; Kortschak et al. 1965; Thomas 1951) and their corresponding stable isotope value ranges (Craig 1953; Sackett and Thompson 1963; Wickman 1952). Following this discovery, Hall (1967) first recognized that high carbon isotope values in maize and other grasses were causing erroneous young radiocarbon dates during analysis. With Hall's conclusions in mind, in 1970, van der Merwe (1982) applied this method to human remains for the first time to determine the individual's diet. Seven years later, Vogel and van der Merwe (1977) tested the SIRA method again to determine maize cultivation in Archaic and Middle Woodland skeletal remains from New York. From the results of their analysis, they were able to determine that maize, a $C_4$ plant, could be detected in a $C_3$ environment and that maize use had increased among the populations over time. The resulting seminal publication of their findings opened the door to a whole host of dietary studies. A majority of these studies focused mainly on the introduction and spread of maize use throughout time. As the number of studies increased, researchers began to better understand the science behind this technique, perfecting their interpretations as they made new discoveries along the way.

Despite the widespread use of stable isotope ratio analysis (SIRA) in archaeology, it has been largely neglected in Central Plains human dietary research. Some exceptions include work by Conner (2001), and Tieszen et al. (1997). In the first piece, Conner presents and interprets isotope ratios from 34 archaeological sites in Kansas, including four that were analyzed for the current investigation. Tieszen et al.'s publication offers human, plant, and animal isotope ratios from 81 sites in the Central and Northern Great Plains. The authors discuss analytical results in terms of geographic regions and time periods and demonstrate synchronic and diachronic diet variation amongst past populations. While these studies offer isotope ratios and dietary interpretation from individuals at 115 sites in the Plains region, these data pale in comparison to that available for Ohio Hopewell, Mesoamerican, and Old World populations.

**Research Goals**

This study aims to alleviate the paucity of dietary data in the Central Plains region and to enhance the understanding of the subjects involved. It 1) investigates the diet and temporality of individuals from burial mound sites using SIRA and bone collagen AMS dating; 2) interprets the diet of these individuals based on their stable isotope ratios; 3) explains patterns and variations in the samples' stable isotope signatures; and, 4) explains the importance of the SIRA results in terms of Central Plains prehistory.

The burial mound sites, which were excavated by Floyd Schultz from 1924 to 1931, include: Dan Younkin (14GE2), Berry (14GE4), James Younkin (14GE6), Dixon (14GE7), and Timber Creek (14CY32)(Figure 1.1). All of these sites are located in northwestern Geary County and southeastern Clay County. These counties are situated in north central Kansas within the Lower Republican River basin. The sample size is small and includes twenty-one individuals from the five sites. Samples date to the Early and Middle Woodland periods. All

dates obtained for this study were calibrated using CALIB 6.1 and presented in the B.C./A.D. format. These dates were acquired directly using the Accelerated Mass Spectrometer (AMS) method on bone collagen. Additional dates were acquired from publications and will also be presented in the calibrated B.C./A.D. format, except when noted.

This thesis contains seven chapters. Chapter Two introduces the reader to the theoretical principles behind stable isotope ratio analysis. Chapter Three describes the physiography, vegetation, fauna, and climate of the Republican River basin. Chapter Four discusses the Central Plains culture history. It includes a review of Central Plains chronology, taxonomy, an overview of the Woodland period, Middle Woodland period, and the Schultz Focus. Chapter Five includes a summary of Floyd Schultz's excavations, a brief history of the Schultz collection, and a description of the sites used in this study. Chapter Six explores the methodologies used for sample selection, age and sex analyses, collagen preparation, extraction and analysis, AMS dating, and statistical analysis. Chapter Seven summarizes the results of the analyses from Chapter Six. Chapter Eight includes a discussion of the results and the thesis conclusion. The discussion incorporates the possible causes for the stable carbon and nitrogen isotopes distribution, an evaluation of SIRA reliability, and offers suggestions for future research.


**Figure 1.1 List of Sites Selected for this Study**

## Chapter Two:

## Theoretical Principles of Stable Isotope Ratio Analysis (SIRA)

The age-old axiom "you are what you eat" conveys succinctly why archaeologists can use SIRA to reconstruct paleodiet. This concept holds true for all living species. As they absorb, ingest, or photosynthesize products from within their environment, specific elements from those sources are fixed within them (Schwarcz and Schoeninger 2011). For plants, differential fractionation of nitrogen during fixation and atmospheric carbon dioxide from photosynthesis help determine their specific pathways: $C_3$, $C_4$, or CAM (Crassulacean Acid Metabolism) (Tykot 2004). The plant's photosynthetic pathway also plays a major role (Schoeninger and Moore 1992). For humans and other animals, as they consume these plants, or one another, portions of their isotopic composition become fixed in the consumer's bone tissue (Renfrew and Bahn 2004:314).

In the past, the stable isotopes most frequently used for paleodietary studies were carbon variants. The selection of carbon was due to its known properties, its atmospheric abundance, and its overall necessity for living organisms. In a number of studies, archaeologists used carbon as the sole source to determine individual diet; however, neglecting other elements, such as nitrogen, decreases the accuracy of a paleodiet reconstruction. By neglecting the stable nitrogen isotope values, one cannot determine whether high $\delta^{13}C$ signatures came from plants or animals, as nitrogen values are used to infer dietary protein sources (Post 2002). While DeNiro and Epstein (1981) noted its importance as early as the beginning of the 1980s, some researchers still neglect to include $\delta^{15}N$ values in their dietary studies, producing less precise results for potentially promising studies.

Carbon is an essential element for biological organisms. It has three naturally occurring isotopes: $^{12}C$, $^{13}C$, and $^{14}C$. Of the three isotopes, only $^{12}C$ and $^{13}C$ are stable (Schoeninger and Moore 1992). The natural abundance of $^{12}C$ is approximately 1.1%, while that of $^{13}C$ is around 98.9% (Hoefs 1987). These isotopic variations exist due to material source signatures and natural differential fractionation – a change in isotope ratios that occurs during metabolism, photosynthesis, and chemosynthesis (Tykot 2004). In each of these processes, materials both organic and inorganic are converted to compounds that allow for the growth and sustainability of their associated organisms. Due to the heavier weight of $^{13}C$, the concentration of $^{12}C$ tends to be higher in living organisms (Schoeninger & Moore 1992). When the values of the two isotopes are input into the formula below, which compares them to the international Pee Dee Belemnite (PDB) standard, they are converted to a ratio that allows them to be interpreted for dietary studies. Because the differences between the tested samples and the international standards are so small, they are expressed in the parts per thousand (‰) format.

$$\delta 13C = \left[ \frac{{}^{13C}/_{12C\ sample}}{{}^{13C}/_{12C\ standard}} - 1 \right] x\ 1000‰$$

The $\delta^{13}C$ ratio produced will vary from plant to plant. Again, this value is determined by the plant's photosynthetic pathway and the atmospheric $CO_2$'s isotopic composition (Lee-Thorp 2008). In prehistory, the $\delta^{13}C$ of the atmospheric $CO_2$ would have been around -5‰ to -6‰; slightly higher without the contribution of carbon from fossil fuels. Today's value is approximately -7‰ (Keeling 1961; Bada et al 1990; Marino and McElroy 1991; Schoeninger and Moore 1992). Malainey (2011:178) places the overall $\delta^{13}C$ range for plants between -37‰ and -8‰. $C_3$ plant values tend to range between -34‰ and -22‰, with an average around -26‰. She places the CAM plant range from -20‰ to -10‰. However, the range can change from day

to night. The range for $C_4$ plants is from -16‰ to -8‰, with an average of -13‰ (Malainey 2011:178). While these ranges are generally consistent, they can vary based on environment types and seasonal conditions.

Like carbon, nitrogen is also a common element, comprising 79% of the Earth's atmosphere. It has two stable isotopes – $^{14}N$ and $^{15}N$ (Schoeninger & Moore 1992). The natural abundance of $^{14}N$ is 99.64%, while the amount of $^{15}N$ that occurs naturally is 0.36% (Hoefs 1987). According to Malainey (2011:41), in order for most organisms to be able to use atmospheric nitrogen ($N_2$), it must first be converted to an exploitable form, or fixed. Through fixation, $N_2$ is converted into nitrates or other compounds. This transition occurs via three known processes: 1) through lightning 2) bacterial denitrification and 3) organismal decomposition following death (Malainey 2011:182). Bacterial denitrification occurs when *Rhizobium* bacteria invade the roots of specific plants, such as legumes, creating nodules where fixation can occur (Fischer 1994). Non-leguminous plants acquire their nitrogen through decomposing plant matter, soil bacteria, and animal waste (DeNiro & Epstein 1981). Blue/green algae also allows for this process in aquatic environments (Schoeninger & Moore 1992). As the atmospheric nitrogen is transformed into a nitrate through these mechanisms, fractionation occurs, producing the $^{15}N/^{14}N$ variation (Evans 2007). When their values are compared to the international standard (AIR-$N_2$), in the formula below, they are converted to a ratio that is applicable in dietary studies.

$$\delta 15N = \left[ \frac{{}^{15N}/_{14N\ sample}}{{}^{15N}/_{14N\ standard}} - 1 \right] x\ 1000‰$$

Similar to the results of the carbon formula, the nitrogen ratios are also presented in the parts per thousand (‰) format.

Like its carbon counterpart, the $\delta^{15}N$ ratio will vary from plant to plant. These variations depend on plant type, denitrification processes, and environment type (Schoeninger & Moore 1992). According to Malainey (2011), because of the $^{15}N$ depletion in atmospheric nitrogen, most $\delta^{15}N$ values are positive. Nitrogen fixers, such as legumes, tend to have values as low as -5‰, while non-fixers range around 2‰ to 6‰. However, Malainey notes, in hot and dry environments, nitrogen values can be as high as +20‰. Stable nitrogen isotope values may also vary depending on the time of year in which a plant is consumed (Malainey 2011:183). To avoid errors in value interpretations, researchers should be familiar with the plant type and environment.

Plant $\delta^{13}C$ and $\delta^{15}N$ values can vary depending on their environment. These variations are due to genetic factors that cause plants to respond to surrounding conditions. For example, $\delta^{13}C$ values are lowered by restrictions in air movement caused by thick vegetation (Malainey 2011:182). This stable isotope value inhibitor, called the canopy effect, occurs in areas such as temperate and tropical forests (van der Merwe & Medina 1991). It occurs when carbon dioxide from plant decomposition is recycled during photosynthesis, sometimes shifting $\delta^{13}C$ values to as low as -35‰ (Schwarcz & Schoeninger 2011:730). According to Ambrose (1991), plant $\delta^{15}N$ values can also vary due to a myriad of environmental factors. Beyond those influences previously mentioned, aspects such as soil salinity, soil type, altitude, and fertilization can increase or decrease stable nitrogen isotope values. For example, in the Sonoran Desert, non-fixing plants have $\delta^{15}N$ values 1-6‰ higher than their soils, while in Hawaii, the same plants have $\delta^{15}N$ differences ranging from -7‰ to -4‰ (Ambrose 1991). Given these examples, one must consider the surrounding environment when interpreting stable isotope ratios.

**Stable Isotopes and Diet**

As herbivorous and omnivorous animals ingest plants, they absorb some of their chemical values. While portions of the plant nutrients, or plant consumer's minerals are digested and incorporated into the consumer's tissues, the source values enrich the consumer's $\delta^{13}C$ and $\delta^{15}N$ values (Ambrose 1993:104). According to Schwarcz and Schoeninger (2011), carbon and nitrogen enrichment values will fluctuate based on the dietary inputs (sources of subsistence) and outputs (excretions and waste). This value variance is called the trophic level effect, and it can be calculated using the following formula:

$$TLE = f_{tissue-diet} = \delta^{x}_{tissue} - \delta^{x}_{diet}$$

The authors note that the enrichment values produced by this formula will vary depending on the isotopes absorbed, consumer species, and individual diet type (Schwarcz & Schoeninger 2011:731). For herbivores, the carbon trophic level effect is around +5‰ in bone collagen (organic portion of the bone) and +12‰ for apatite (inorganic portion of the bone) and enamel (Tykot, personal communication May 5, 2013). The trophic level effect for nitrogen in these animals is at least 3‰ (Bocherens and Drucker 2003). Thus, stable isotopic values in herbivores are higher than those of the plants on which they feed.

The trophic level effect affects carnivores and omnivores, directly and indirectly. Stable isotope enrichment continues as the consumer is ranked higher on the food chain. Depending on the consumer's mode of subsistence and their food sources, their isotopic values will vary. Terrestrial carnivores who do not consume fish, their peak values should be one level higher than herbivores: $\delta^{15}N$ should be approximately 8-12‰, while their $\delta^{13}C$ should be around -19‰ (Schwarcz and Schoeninger 2011; Tykot, personal communication May 5, 2013). The authors state that the latter value will vary if the carnivore consumed an herbivore who ate $C_4$ grasses.

The $\delta^{13}C$ and $\delta^{15}N$ values of marine carnivores will be even higher than those who rely solely on terrestrial sources (Schwarcz & Schoeninger 2011:731-732). Ratios for $\delta^{13}C$ may be higher than those who consume only land-dwelling species (Fry et al. 1978). Isotopic values for omnivores tend to fall between those of strict herbivores and carnivores; however, nitrogen enrichment will be higher in omnivores who consume marine food sources (Malainey 2011:183). Thus, the researcher must be aware of the subject's subsistence behaviors prior to providing dietary inferences.

Human and animal subsistence strategies will also affect their $\delta^{13}C$ and $\delta^{15}N$ values. These results are due to the dietary choices made by both species, either due to food preferences or seasonal availability. For example, humans may choose to consume specific plants or animals based on their nutritional value and the time and energy needed to acquire these sources. They may also prefer specific foods over others. Animals may selectively eat certain plants based on their availability or preference. In environments where $C_3$ and $C_4$ plants are available, interpreting individual diet in archaeological studies can be complicated. Based on the botanical remains in the archaeological record, consumers ate both plant types whenever they were available. However, it is possible to determine the degree of $C_4$ plant consumption using the following formula:

$$\%C_4 = \frac{(\delta C_3 - (\delta_b - \Delta_{d-c}))}{(C_4 - C_3)} \text{ x } 100$$

In this equation, the $\delta_b$ value is the bone apatite or collagen $\delta^{13}C$ ratio, and the $\Delta_{d\text{-}c}$ is the diet-apatite and diet-collagen spacing. When the resulting values from this formula are compared to the end-member $\delta^{13}C$ ratios for $C_3$ and $C_4$ foods, -25‰ and -10‰, one can estimate the role that $C_4$ plants played in a consumer's diet (Ambrose et al. 2003). Thus, it is possible to limit some of the complications present in interpreting individual diet of consumers from a mixed prairie.

**Bone and Dietary Studies in Archaeology**

Due to the common lack of tissue preservation in the archaeological record, SIRA requires skeletal remains for paleodiet reconstruction. Occasionally hair and fingernails are preserved and can be used, but only in rare cases. More often than not, bone survives the decomposition process better than softer organic materials. However, the degree of skeletal preservation is due to a number of intrinsic and extrinsic factors. Intrinsic factors may include the bone's porosity, structure, and size, while extrinsic factors can involve site inundation, sediment pH, regional temperature, and human and bacterial activity (Von Endt & Ortner 1984). These factors affect each of the bone's composite materials – bioapatite, collagen, and osteocalcin – and their individual preservation rate varies from situation to situation (Collins et al. 2002). Of the three materials, collagen degrades faster and persists less frequently than bioapatite and osteocalcin. However, under optimal conditions, collagen has survived as long as 200,000 years (Hedges 2002; Jones et al. 2001). Even when molecular degradation does occur, the collagen's isotopic contents tend to stay intact (Lee-Thorp 2008). Given their survivability, archaeologists can extract these materials for radiocarbon dating and stable isotope paleodietary analysis.

Researchers use bone collagen more frequently than other materials in SIRA. It is generally extracted from trabecular bone, such as a long bone or rib, but is occasionally sampled from tooth roots. Scientists select collagen due to its size and durability, its contents, and its inert nature. It comprises approximately 25% of a living bone's weight; following death, well-preserved fossils contain collagen equal to about 22% of the overall weight of the bone (Schwarcz & Schoeninger 2011:727; Schoeninger and Moore 1992). Because of its size, archaeologists tend to encounter it with more regularity than any other bone material (van der

Merwe 1982). Its preservation is advantageous for archaeologists, because, along with various other chemical elements, it contains the carbon and nitrogen isotopes from dietary protein necessary for radiocarbon dating and SIRA. Due to its slow turnover rate – between 2 and 10% per year – it represents the consumer's stable isotope acquisitions over an extended period of time (Stenhouse & Baxter 1976; Finucane 2007). Bell et al. (2001) estimate that bone collagen may represent a period up to 15 years, while Chisholm (1989) feels that it may range from 10 to 30 years. Despite the length of time that its values may represent, it provides one of the building blocks necessary for interpreting stable isotope values in ecological and paleodietary research.

Archaeologists also use bone bioapatite often for SIRA. They generally extract this material from the external cortical layer of long bones and ribs. It is also present in tooth enamel (Widga 2006). Bone apatite tends to reflect the $\delta^{13}C$ values of a consumer's lifetime (whole diet), except for that of teeth (Jim et al. 2004). The enamel in teeth is formed at different times throughout childhood. Developmental $\delta^{13}C$ values of enamel in teeth represent isotopic compositions at different times through the span of this period (Armstrong et al. 1995). Tooth enamel is formed mostly with hydroxyapatite, while bone apatite is composed via bicarbonate and serum $CO_2$ and is highly substituted, with very low crystallinity (Driessens et al. 1978; LeGeros 1983 & 1991; Lee-Thorp 2008). Following death, crystal growth and recrystallization occurs rapidly, which can allow foreign elements into the apatite's crystal structures, leaving it more susceptible to diagenesis (Sharp et al. 2000). However, a recent study by Koch et al. (1997) suggests that these impurities can be removed. Still, archaeologists prefer teeth when sampling for SIRA (Malainey 2011:180-181). When the $\delta^{13}C$ values from these materials are compared to the $\delta^{13}C$ and $\delta^{15}N$ ratios from bone collagen extractions, researchers are presented with a more thorough representation of an individual's lifetime diet. As the results are juxtaposed

with the known carbon and nitrogen ratios from archaeological botanical remains, we are given a clearer window into individual subsistence strategies of the past.

While SIRA can provide archaeologists with a clearer window to the past, other factors must be taken into consideration. Even when researchers account for environmental factors and trophic level effects, there are still individual biological and demographic factors to consider in dietary interpretation. One such factor is individual age. Due to breastfeeding practices, infants tend to have higher $\delta^{13}C$ and $\delta^{15}N$ values than most adults (Katzenberg et al. 1993; Richards et al. 2002). Stable isotope analyses on breastfeeding infants have shown a trophic level shift around +1‰ in carbon values, and +3‰ in nitrogen values (Tuross & Fogel 1994; Fuller et al. 2006). In several archaeological studies, trophic levels tended to fall back to normal adult levels after infants reached the age of two (Katzenberg et al. 1993; Fuller et al. 2003; Richards et al. 2002). Malnutrition is another factor to consider while interpreting paleodiet. Nutritional stress and disease has been shown to alter $\delta^{13}C$ and $\delta^{15}N$ values (Matthews & Bier 1983; Katzenberg & Lovell 1999; Fuller et al. 2005; Hatch et al. 2006; McCue & Pollock 2008; Huelsemann et al. 2009; Katzenberg 2012). Archaeologists must be able to recognize indicators of iron deficiency, disease, and malnutrition in bone and teeth, such as linear enamel hypoplasia defects and Harris lines to support any such conclusions (Huss-Ashmore et al. 1982). While these are just a few examples, individual biological factors affecting stable isotope values are not limited to these instances. Thus, archaeologists should be familiar with the overall biological conditions of their samples when inferring individual paleodiet.

## Chapter Three:

## Environment

The Republican River basin stretches across three states and drains generally east and southeast. From its headwaters in eastern Colorado, it cuts into northwestern Kansas before it veers north into southern Nebraska. After flowing eastward for much of the state, it curves south and flows into the Smoky Hills region of north central Kansas (Fig. 3.1). According to Waldo Wedel (1986), the Republican River basin encompasses approximately 26,000 square miles and ranges in elevation from approximately 6,000 feet at Cedar Point, Colorado and drops to 1,050 feet near its historic merging with the Smoky Hill river east of Junction City, Kansas. It measures its widest at 120 miles at the Colorado state line, and its narrowest (30 miles) below Harlan County, Nebraska (Wedel 1986:7). As the basin transects northeastern Kansas, its size varies due to bedrock controls from county to county. Overall, it is considerably expansive, dwarfing similar geological features in the Plains region. Such size and geographical variety provides a wide array of niches for equally diverse inhabitants.

Like much of the Great Plains, the topography of the Republican River basin is regionally divergent. The basin's surface features change frequently as the river migrates and downcuts through the prairie. At its point of origin in northeastern Colorado, the landscape is composed of flatlands and rolling hills, which change into a flat area covered with dunes as the river flows east into the High Plains and loess deposits of northwestern Kansas (Reardon et al. 2012). In southeastern Nebraska, the basin contains more flat, dune-covered land that eventually transitions into a flat, bluff-lined valley. In this area, narrow divides are typical and fluvially carved steep canyons and loess tables are frequently present. As the basin continues eastward,

these geological features give way to the broad plains uplands, which are overlain with Peoria Loess and superimposed by Bignell Loess in places (Martin 1991). From there, the basin dips into the Flint Hills of northeastern Kansas, which are defined by "broad alluvial bottoms and prominent divides with frequent rocky ledges" (Wedel 1986:8). In this region, presently, the Republican River flows into the Milford Reservoir, whose surroundings consist of "high, but gently rolling hills" (Molyneaux et al. 1995: 14). Prior to reservoir construction in 1962, the Republican River met with the Smoky Hill River near Junction City, forming the beginnings of the Kansas River. Here, the Republican River basin terminates, giving way to the limestone and chert-rich landscape of the Flint Hills. In the past, the basin's occupants found such topographic diversity beneficial, providing them with a range of food sources, and strategically advantageous habitation and hunting locations.

Because of its location within the Americas, the climate of the Republican River basin is subhumid and continental. Atmospheric conditions are also erratic and can be prone to short-term changes. These idiosyncratic conditions are partially attributed to the basin's distance from any major bodies of water, which help moderate regional climates (Mandel 2006:18). The convergence of the air masses in the region - mild air from the Pacific Ocean, cold dry air from Canada, and moist warm air from the Gulf of Mexico also affects the basin's climate (Wedel 1986:12). Such air mass interaction can also cause erratic weather patterns, which may spur violent, destructive storms and wide temperature fluctuations. Due to these factors, the basin's seasons tend to be extreme – summers are hot and winters are cold (Kincer 1923; Bates 1935:86; Thornthwaite 1941; Wedel 1986:10; Mandel 2006:18).

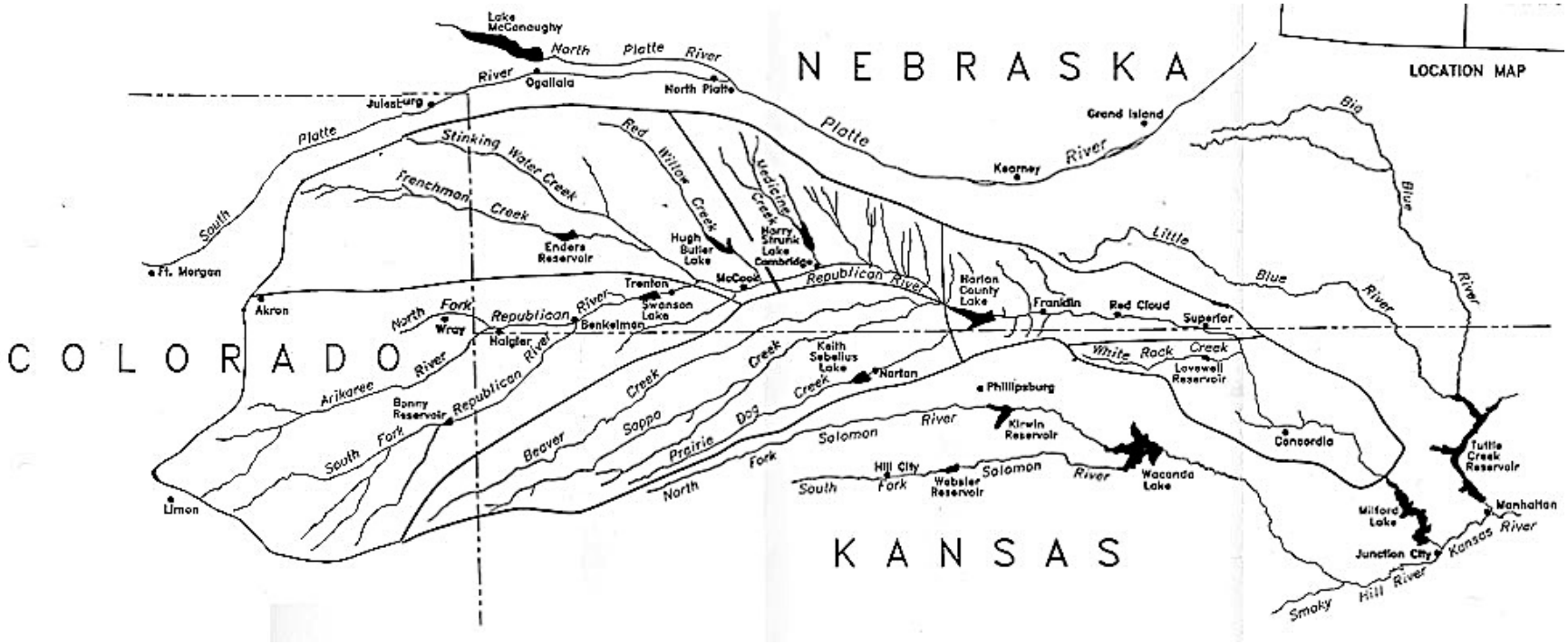


**Figure 3.1. Map of the Republican River Basin** **Source: Wikimedia Commons**

Recorded temperatures for the area have been as low as -25°F, and as high as 113°F (National Climatic Data Center 2012). Annual precipitation averages can vary from 14 inches, near the headwaters of the Republican River, to 32 inches near Junction City, Kansas. Basin conditions can vary widely. Overall, its climate conditions help define its environment, and, in turn, its plant and animal species. While humans discovered ways to adapt to these extremes, the basin's climate requires the remainder of its inhabitants to be robust and resilient in order to survive.

**Local Vegetation**

The vegetation of the Lower Republican River basin is mixed. Plant life ranges from short and tall grasses to an array of herbs, blossoms, shrubs, and trees (Table 3.1). The phenology of these plants is also variable, depending on whether species are "cool-season" or "warm-season" influenced. The basin's native vegetation, particularly that of the Flint Hills Uplands, is primarily tallgrass, or bluestem prairie (Kuchler 1964; Tieszen et al. 1997; Mandel 2006:20; Cordova et al. 2011). Warm season grasses such as big bluestem (*Andropogen gerardii)*, little bluestem (*Andropogen scoparius*), switchgrass (*Panicum virgatum*), and Indian grass (*Sorghastrum nutans*) dominate the area (Molyneaux et al. 1995:16; Bamforth 1988:32; Tomanek and Hulett 1970:215). The dominant tallgrass species tend to start growing in the late spring and early summer, providing highly nutritional forage for the regions animal species. The grasses' ability to permeate the Flint Hills region is due to the rich soils, moderate rainfall, and a long growing season (170-190 days) of the area (Benison et al. 2000:5). However, because of their inability to survive when they are left standing, tallgrasses tend to be scant in the winter (Wedel 1986:16). During times of drought, tallgrasses also tend to react adversely and give way to shorter grasses (Bamforth 1988:39). In the past, the region's inhabitants – both animal and

human – consumed some of these plants; however, they also provided several of other functions. Both occupants used them to supplement other materials in habitation construction, while human inhabitants also used them as sources of fuel and kindling.

The biogeographic distribution of the prairie's trees, shrubs, and annual and perennial herbs is both endemic and cosmopolitan. Like their graminoid counterparts, these plants are also subject to varied seasonality. According to Mandel and Brooks (1988:11), most of the early growing season species tend to be small plants. They begin to appear by late April, but are gone again in a few weeks. The common breadroot is one of the most frequently used species of these plants. Around mid-August, the authors note, the warm season herbs begin to grow, spreading throughout the Great Plains. Near the end of the growing season, the asters emerge, indicating that winter will soon be on its way (Mandel and Brooks 1988:11-12; Ode et al. 1980). There are also a number of trees and shrubs endemic to this region. Much like the grasses of the region, in the past, many of these species would have played an important role in the lives of the area's inhabitants. They procured many of these species as sources of food, while they used others in various daily activities. The use of these plants can be attested to by their inclusion in the caches and pits found in and near the former habitation sites of these people. Proof can also be found in the food residues that remain caked to the walls of the occupants' ceramic vessels used for cooking.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Grasses | | Trees and Shrubs | |
| bluestem | *Andropogen* spp. | spurge | *Euphorbia* sp. |
| true grass | *Poaceae* sp. | hickory | *Carya* spp. |
| bulrush | *Scripus* sp. | black walnut | *Juglans nigra* |
| bedstraw | *Galium* sp. | pawpaw | *Diospyrys* sp. |
| sedge | *Carex* sp. | oak | *Quercus* sp. |
| | | plum | *Prunus* spp. |
| Annuals/Perennials | | elderberry | *Sambucus* spp. |
| violet | *Viola* sp. | blackhaw | *Vibrunum rufidulum* |
| sunflowers | *Helianthus annuus* | hackberry | *Celtis* sp. |
| pigweed | *Amaranthus* spp. | blackberry | *Rubus* sp. |
| chenopods | *Chenopodium* spp. | hazelnut | *Corylus americana* |
| docks | *Rumex* spp. | wild grape | *Vitis* spp. |
| purslane | *Portulaca* spp. | persimmon | *Asimina* sp. |
| smartweeds/ | *Polygonum* spp. | hawthorn | *Crataegus* sp. |
| knotweeds | | sumac | *Rhus* sp. |
| ground-cherry | *Physalis* sp. | | |
| prickly-pear cacti | *Opuntia* sp. | | |
| pokeweed | *Phytolacca americana* | | |
| vetch | *Vicia* sp. | | |
| maypop | *Passiflora* sp. | | |

**Table 3.1. Regional Flora Recovered from Central Plains Archaeological Sites (Adair 2003; Adair and Drass 2011:314)**

**Domesticated Plants**

Cultigens provided the basin's occupants with a more perdurable menu than its previous inhabitants (Table 3.2). However, while these people used such cultigens, archaeologists are still unaware of the full extent of their use and the time of their introduction (Bozell and Winfrey 1994). For example, maize phytoliths from ceramic residue dating to cal. A.D. 31-129 (Adair 2012), but maize did not become a dietary staple until the Plains Village period (Adair and Drass 2011:327). Based on the archaeological record, Central Plains Woodland populations relied on hunting and gathering, along with a mix of wild plants and cultigens for subsistence (Johnson and Johnson 1998: 205-206; Adair 2006:256). Therefore, a majority of the high $\delta^{13}C$ readings that appear in stable isotope studies of material dating to the Woodland period are likely the result of animal and wild plant consumption, rather than maize. Despite the extent of their use, one should keep them in mind when inferring the diet of past populations from stable isotopes. Ultimately, their consumption, however minimal, still alters the interpretation of the carbon and nitrogen signatures present in the individuals being studied.

| Common Name | Scientific Name |
|---|---|
| marshelder | *Iva annua var. macrocarpa* |
| squash/ pumpkin | *Cucurbita pepo* |
| goosefoot | *Chenopodium berlandieri* |
| native squash | *Cucurbita pepo var. ovifera* |
| bottle gourd | *Lagenaria siceraria* |
| sunflower | *Helianthus annuus var. macrocarpus* |
| maygrass | *Phalaris caroliana* |
| erect knotweed | *Polygonum erectum* |
| maize | *Zea mays* |

**Table 3.2. Domesticated Plants Recovered from Central Plains Woodland Archaeological Sites (Adair 1996:110; Adair and Drass 2011:314; Bozell and Winfrey 1994)**

**Local Fauna**

Based on the archaeological record and extant populations, the Lower Republican basin's fauna consisted/consists of a diverse aggregate of animals (Table 3.3). Like now, in the past these animals varied in size and occupied the basin's various niches, making use of many of territory's plant species. In prehistory, these sources were used for: subsistence, clothing, fuel, and shelter (Bamforth 1988:5). Of these animals, Central Plains inhabitants consumed bison and deer more frequently (Bamforth 1988:5: Bozell et al. 2011:363). The basin's occupants would have made use of a variety of smaller animals as well. These creatures include an assortment of rodents, birds, fish, freshwater mussels, and reptiles. While these animals played a role in the lives of the basin's human occupants, due to differential recovery and preservation in the archaeological record, it is difficult to measure their overall contribution to subsistence for prehistoric populations (Lyman 1994:435). The impact of these animals was not just limited to the human populations of the Central Plains. The animals' interaction with the surrounding environment helped support the ecosystem necessary for their survival. Their continued grazing of tallgrasses allowed other plants to germinate, while their defecates provided the species of the Great Plains with additional nutrition to further their continued existence.

| Common Name | Scientific Name | Common Name | Scientific Name |
|---|---|---|---|
| Mammals | | Fish | |
| bison | *Bison bison* | bass | *Micropterus spp.* |
| pronghorn | *Antilocapra americana* | northern pike | *Esox lucius* |
| white-tailed deer | *Odocoieleus virginianus* | sturgeons | *Acipenseridae* |
| mule deer | *Odocoielues hemionus* | catfish | *Ictalurus punctatus* |
| elk | *Cervus canadensis* | suckers | *Hypostomus plecostomus* |
| plains grizzly | *Ursus horribilis* | minnows and chubs | *Cyprinidae* |
| black bear | *Ursus americanus* | gar | *Hiodon alosoides* |
| coyote | *Cynomys ludovicianus* | | |
| cougar | *Felis concolor* | Reptiles | |
| bobcat | *Lynx rufus* | rattlesnake | *Crotalus viridus* |
| raccoon | *Procoyon lotor* | water snakes | *Natrix spp.* |
| beaver | *Castor canadensis* | bull snake | *Pituophis melanoleucus sayi* |
| river otter | *Lutra canadensis* | garter snake | *Thamnophis sirtalus parietalis* |
| black-footed ferret | *Mustela nigripes* | box turtles | *Terrapene spp.* |
| mink | *Mustela vision* | snapping turtle | *Chelydra serpentine* |
| muskrat | *Ondatra zibethicus* | painted turtle | *Chrysemys picta* |
| | | sliders | *Trachemys spp.* |
| Birds | | | |
| turkey | *Meliagris galopova* | Freshwater Mussels | |
| great prairie chicken | *Tympanuchus cupido* | cylindrical papershell | *Anadontoides ferussacianus* |
| dabbling ducks | *Anatinae* | pimpleback | *Quadrula pustulosa* |
| divining ducks | *Aythyinae* | giant floater | *Pyganodon grandis* |
| geese and swans | *Anserinae* | white heelsplitter | *Lasmigona complanata* |
| owls | *Strigidae* | fatmucket | *Lampsilis siliquoidea* |
| hawks and eagles | *Accipitridae* | | |
| falcons | *Falco spp.* | | |

**Table 3.3. Animals Commonly Recovered from Central Plains Archaeological Sites (adapted from Bozell et al. 2011:359)**

## Chapter Four:

## Central Plains Culture History

| Period | Temporal Range |
|---|---|
| **Historic** | 300 BP – present |
| **Protohistoric (Late Ceramic)** | 500 – 300 BP |
| **Plains Village (Middle Ceramic)** | 1,000 – 500 BP |
| **Woodland (Early Ceramic)** | 2,000 – 1,000 BP |
| **Archaic** | 10,000 – 2,000 BP |
| **Paleoindian** | 12,000 – 10,000 BP |
| **Pre-Clovis** | pre 12,000 BP |

**Table 4.1. General Chronology of the Central Plains (Ritterbush & Logan 1991)**

### Central Plains Woodland

The Plains Woodland period is divided into three period divisions: Early, Middle, and Late. They are primarily differentiated by differences in ceramic and lithic styles, settlement patterns, changes in subsistence strategies, and general adaptation variations (Adair personal communication). The regional Early Woodland period dates from 500 B.C. to A.D. 1, the Middle Woodland period stretches from A.D.1 to A.D. 750, and the Late Woodland period ranges from A.D. 750 to A.D. 1000 (Hoard and Banks 2006:8). The original Woodland chronology was devised by McKern (1939) around 1932, and was later modified by Deuel (1935), and Griffin (1943) (Stoltman 1978; Dempsey 2008). Willey (1966) would later apply this chronology to the Central Plains based on the presence of artifact characteristics similar to those of the Woodland period in the eastern United States. These artifact characteristics include: burial

mounds, corner-notched projectile points, and elongated pottery vessels with conoidal bottoms (Johnson and Johnson 1998:201).

The Plains Woodland period is defined by discernable social and technological change from the preceding Archaic period. Researchers attribute much of this transformation to the synergic communication between Central Plains Archaic period inhabitants and the so-called Hopewell Interaction Sphere (Struever 1964; Caldwell 1964; O'Brien 1984: 45; Carr and Case 2005). As the groups interacted, the local Archaic people incorporated some of the Hopewell practices and technologies with their own, creating some of the amalgamations found in their habitation and burial sites. The degree to which this interaction affected the non-Hopewell people varies both geographically and temporally, and its manifestations within their material culture range widely (Bozell and Winfrey 1994; Logan 2006). These variations help define the archaeological complexes, foci, and phases that Plains archaeologists use today, which include, but not are limited to: the Kansas City Hopewell Variant, Valley Variant, Schultz Focus, Keith Focus, Walnut Phase, Butler Phase, Cooper Phase, Cuesta Phase, Deer Creek Phase, Wakarusa Phase, Grasshopper Falls Phase, and the Greenwood Phase (A.E. Johnson 1992; Kivett & Metcalf 1997; Logan 2006:77-88; O'Brien 1984:45; Wedel 1986:96).

Social and technological changes can also be attributed to the adaptation of more sedentary lifestyles. The shift from seasonal band group occupations of the Archaic to hamlets and villages, which were more frequently occupied year-round, becomes apparent in the Middle to Late Woodland (O'Brien 1984:50; Bozell and Winfrey 1994). During this time, the Hopewell began to establish large base villages near major creeks. These settlements were often accompanied by smaller task specific sites and camps, which served as storage caches, workshops, and fishing stations. Non-Hopewellian groups appear to have had the same site

distribution patterns, but on a smaller scale (O'Brien 1984:50). Hunting tools also changed during this time, as some groups began to adopt the bow and arrow; however, these people used darts and atlatls throughout the Woodland period, until there were phased out completely around A.D. 900 (Logan 2006:85; Tarabek 2012).

**Central Plains Middle Woodland**

There are at least five known regional variants of Middle Woodland groups in Kansas. While these complexes appear within the state, their known ranges extend beyond Kansas. These groups are represented by: Kansas City Hopewell, the Cuesta Phase, the Valley Variant, the Cooper Phase, and the Schultz Focus (Johnson and Johnson 1998; A.E. Johnson 2001; Logan 2006:79). Based on the archaeological evidence, the Kansas City Hopewell appear to have stayed mainly in northeastern Kansas and northwestern Missouri; however, their influence can be seen in cultural remains spread throughout the Central Plains (Johnson and Johnson 1998:201). The range of the Valley Variant spreads across five states. While their core area appears to be in the eastern half of Nebraska, attributed sites appear as far north as central South Dakota and as far east as western Iowa (Bozell and Winfrey 1994). Sites are also attributed to Valley as far south as Doniphan County, Kansas, as represented by the Taylor Mound (14DP3) (O'Brien 1971). The Cooper and Cuesta variants appear in northern Oklahoma and southeastern Kansas. While the groups identified with these two variants are separate in name, their close proximity and cultural remains suggest that they may actually be only one (Logan 2006:82). The Schultz Focus can be found in north central Kansas along the Lower Republican River Basin and is primarily defined by burial mounds (Eyman 1966). While these groups were separated geographically, they share similarities that suggest a connection between them. The nature of these relationships remains a topic still debated among Plains archaeologists.

**The Schultz Focus**

The Schultz Focus was defined as a mortuary complex, based on a series of burial mounds located in the Republican River Valley (Eyman 1966). Its name pays tribute to Floyd Schultz, the avocational archaeologist who excavated the 32 burial sites. Eyman (1966) defined the complex's temporal and spatial parameters after analyzing the contents of the mounds. He identified multiple different ceramic types that had been present in the mounds, including those that are associated with the Kansas City Hopewell, Plains Woodland, and the Central Plains Tradition. He also described the various projectile points that Schultz found within the mounds, most of which he thought were representative of Scallorn forms. Although he did not obtain any radiocarbon dates through absolute dating, he suggested a temporal range of A.D. 200 to A.D. 600 for the Schultz Focus (Eyman 1966:333-334). Eyman was able to create this time frame by comparing the mound's artifacts to those from sites with radiocarbon dates in the river basin vicinity. This method would remain the only means of dating this focus until the bone collagen radiocarbon dates were obtained for this project (Adair 2012).

Apart from their burial practices and their social interactions with other cultures, we know very little about the Schultz Focus people. However, researchers have made attempts in the past to make their identification possible. In his thesis work on the Schultz Focus, Eyman (1966:334) suggested that these people were not a "Hopewellian colony," but instead, they represented a "lineage kinship society which had shifted from a prior subsistence economy based upon commensal plant collection and Plains faunal hunting to a Chapalote-teosinte maize-growing culture complex." He believed they acquired the knowledge to cultivate these crops through a trade route that spread this practice from the Southwest to the Southeast. The group was unable to expand beyond the Lower Republican River Basin due to the inhospitable

environment of the Plains outside of the basin's confines (Eyman 1966:334). Prior to Eyman's work, similar practices and assemblages had been associated with the Hopewell, the Keith Focus, and the Valley variant (Kivett 1952:137; Schultz and Spaulding 1948; Wedel and Stewart 1959:554).

Phenice (1969) also provided clues to their identification based on a craniometric analysis of the human remains. He felt that they all belonged to a physical stock represented by the Kansas City Hopewell crania analyzed by Stewart (1943). The only difference between the groups was that Schultz people flattened their occipital bone. He also posits that the similarities between the skulls of the Central Plains Archaic people and those of the Schultz group suggest that the latter descended from the former. Overall, he found little indication that the Schultz group had migrated from the East, as some have suggested (Phenice 1969:76). However, I should point out that Phenice did not use any statistical tests of significance to support his conclusions. Despite the level of accuracy of Phenice's claims, researchers should provide additional support, such as DNA, to abdicate or assert any future group identity claims.

## Chapter Five:

## The Sites

Floyd Schultz excavated the skeletal material used for this study from 1924 to 1931. Schultz was an avocational archaeologist and anthropologist who conducted fieldwork at a large number of habitation and burial sites throughout his career (Hawley 1993). At the time of his excavations, archaeological methodology was still in its infancy, restricting him to less sophisticated burial mound identification and exhumation practices. Quite often, Schultz identified the mounds based on the large limestone and sandstone blocks that were eroding from the dirt. Middle Woodland Native American populations often used such stones to solidify or mark the mounds. In other cases, he identified the mounds by the erosional exposure of the interred human remains. Schultz unearthed the cultural remains on a macro-level, using guidance provided by the National Research Council's (1930) "Guide Leaflet for Amateur Archaeologists." As per their instruction, Schultz excavated the mounds with picks and shovels. He divided his units into five foot squares and dug each of them down to depths of two feet at a time. This lack of resolution pales in comparison to that used in modern excavations, in which soil is removed centimeters at a time.

Despite the lack of resolution used in his excavations, Schultz had the foresight to make field notes, which contained inventories, field specimen numbers, diagrams, photographs, and maps. Photographs included images of some of the mounds prior to excavation and the exhumed, in-situ skeletal remains. Schultz noted the dimensions of the mounds, their geographic locations, and the general level of artifacts and skeletal remains. Skeletal provenience was basic and indicated the depth of the remains and their general cardinal location within the mounds;

however, the remains were not uniquely cataloged. He also described the position of the interred individuals – flexed, bundled, extended, supine – their preservation, and their degree of completeness. Diagrams and maps also depicted much of this information, although with limited detail. Overall, this information allowed me to partially reconstruct the general location of the human remains within the mounds and determine if I could associate any additional artifacts with them.

The artifacts and skeletal materials have had a long and obscure history following the excavations. In 1948, Schultz contacted Carlyle Smith, the newly appointed curator of the Kansas University Natural History Museum. After several meetings in which Smith examined Schultz's collections, Schultz decided to donate both the cultural and human remains to the museum. How and where Schultz curated the collections while they were in his possession is unknown. Due to inadequate museum accession records, the state of the materials at the time of their donation is also unknown. Since their accession, the human remains have been used for teaching purposes at the University of Kansas and the University of Tennessee and have been studied independently by students. Phenice (1969) analyzed them for his dissertation and a University of Kansas publication. Students had also analyzed and inventoried the remains for the Native American Grave Protection and Repatriation Act (NAGPRA) law compliance. When I began my study, I discovered that many of the elements were intermixed, even between sites. While it was possible to re-affiliate some of the comingled remains with their original sites, some bones lacked individual catalog numbers and many of the cranial and post-cranial elements could not be associated with particular individuals. Once I, along with three other students, sorted the skeletal materials to the extent possible, preparation for the current study could begin.

Adair chose five sites for this project, which are all mortuary mound contexts. Multiple individuals in each of the mounds were treated and interred using four methods. For example, According to Schultz's (n.d.) notes, some of the intact individuals were buried in a flexed position while others were extended. The remainder of the bones were either broken and cremated, or disarticulated. Artifacts were often minimal, and in most cases, not clearly associated with the interred remains. While it seems likely they were linked to the dead, the resolution of the recovery methods makes it impossible to substantiate direct intentional association, apart from a few cases. Based on Schultz's descriptions, the mound's constructors sealed the mortuary contexts of the mounds with rocks and sediment. In some cases, they placed bones and artifacts in the upper levels of the stones and dirt fill. While they are probably later interments, we do not yet understand their significance.

**Dan Younkin (14GE2)**

The Dan Younkin site sits in Geary County, Kansas and once contained at least three burial mounds (Figure 5.1). It rests atop the high point of a bluff overlooking the Republican River valley. According to Schultz (n.d.), Mounds 1 and 3 set approximately 25 feet from one another, while Mound 2 is 360 feet east and 150 feet north of the first two. He excavated the mounds in May 1928 after he discovered an exposure of flat rocks that served as caps for the mounds. Inside mound 1, he found a large number of fragmented human remains, but no artifacts. Mound 3 also contained a large number of fragmented bones, many of which were burned; artifacts included chipped stone projectile points, knives, and flakes. This mound also contained a partial stone-lined chamber burial just north and west of its center, which held the remains of multiple individuals (Schultz n.d.). Phenice (1969:27-28) estimated that the first mound represented the remains of 11 individuals, including male and female subadults and

adults. Mound 3 contained at least 17 individuals, including subadults and adults, both male and female (Phenice 1969:27). Unfortunately, no data exists for Mound 2.

**Figure 5.1. Dan Younkin Mound Excavation (Schultz n.d.)**

**Berry Site (14GE4)**

The Berry Site lies in northern Geary County, Kansas and previously included two burial mounds. It currently rests near the shoreline of Milford Lake. Based on Schultz's (n.d.) notes, the mounds are located within 60 feet of one another. He excavated the mounds in 1928 after observing the exposure of their limestone caps while surveying the area. While excavating mound 1, he unearthed a large number of fragmented and burned human remains, along with a single artifact – a spoon scraper. Mound 2 (Fig. 5.2) also contained many burned and fragmented bones; artifacts included ceramic sherds, beads, a stone knife, a bone awl, and a modified antler tine. The second mound also contained an unique, stone-lined, triangular "ossuary" chamber, which included multiple fragmented skulls and cross bones. A large cache of mussel shells lay beneath the east wall of the chamber (Schultz n.d.). Phenice (1969) estimated that Mound 1 contained the remains of at least 8 individuals; Mound 2 held at least 37 individuals. Both mounds contained both male and female individuals whose ages ranged from less than a year to over 40 (Phenice 1969:32-33).

**Figure 5.2. Berry Mound No.2 (Schultz n.d.)**

**James Younkin (14GE6)**

The James Younkin site is a single burial mound that rests in Geary County, Kansas (Fig. 5.3). It occupies a knoll that overlooks the present day shoreline of Milford Lake. Schultz (Schultz n.d.; Schultz & Spaulding 1948) excavated the mound in 1931, but recorded only a few field notes, mostly consisting of quickly drawn sketches. Inside the mound, rested over 2,000 fragmented human remains and a single extended burial. He excavated a number of artifacts, including: cord-marked ceramic sherds, a stone pipe, worked bone, projectile points, a chipped-stone knife, pendants, a miniature ceramic vessel, and bone and shell beads. The floor of the mound was lined with a layer of stone (Schultz n.d.; Schultz & Spaulding 1948). Phenice (1969:35) estimated there to be approximately 20 individuals interred in the mound.

**Figure 5.3. James Younkin Site (Schultz n.d.)**

**Dixon (14GE7)**

Approximately 8,000 feet southeast of the James Younkin mound lies the Dixon site, which once contained a single mound. This feature protrudes from the edge of a bluff that overlooks the Republican River Valley (Fig. 5.4). Schultz (n.d.) excavated the center portion of the mound in June, 1931, providing only a few pages of quickly drawn sketches. Inside the mound, he found approximately 543 bone fragments. Artifacts included a chipped stone drill, perforator, flakes and projectile points, several shell ornaments, and bone and shell beads (Schultz n.d.). Phenice (1969:37) estimated the mound contained the remains of approximately eight individuals, including seven adults and one subadult.

**Figure 5.4. The Dixon Mound (Schultz n.d.)**

**Timber Creek (14CY32)**

The Timber Creek site lies in Clay County, Kansas and contained two small, overlapping mounds. They are located within the boundaries of the 19th century Timber Creek Cemetery (Fig. 5.5). Schultz (n.d.) excavated Mound 1 in November and December of 1925 and Mound 2 in March, 1926. He unearthed a large number of skeletal fragments from Mound 1, a portion of which were calcined. Artifacts included a number of projectile points, and a cordmarked Woodland period rim sherd. Mound 2 also contained a large number of skeletal fragments, some of which had also been burned. He found a concentration of long bones and crania near the bottom of the mound. Artifacts included projectile points, tubular bone beads, and cord-roughened ceramic sherds (Schultz n.d.). Phenice (1969:20-23) estimated that Mound 1 contained a minimum number of 14 individuals, ranging from newborns to adults, while Mound 2 held at least 20 individuals mostly dating below 40 years of age. Both mound were comprised of male and female individuals (Phenice 1969:20-23).

**Figure 5.5. The Timber Creek Mounds (Schultz n.d.)**

## Chapter Six:

## Methodology

I, along with two other graduate students, began the stable isotope ratio analysis (SIRA) process by selecting long bone and tooth samples from the five sites noted in Chapter 4. Based on the project budget, we selected twenty-one samples from five of Schultz's burial mounds. To review, the chosen sites were: Berry (14GE4), Dan Younkin (14GE2), Dixon (14GE7), James Younkin (14GE6), and Timber Creek (14CY32). Adair selected these sites based on the need for the reevaluation of their skeletal remains and on the amount of available information on them in the Archaeological Research Center. Key information included the amount of detail in Schultz's field notes and whether the museum contained any associated artifacts that could be culturally and temporally diagnostic. The degree of detail that Schultz provided for some sites was at times, sparse; for others, he recorded an abundance of information. The amount of associated artifacts also varied among the sites. Given these factors, we selected samples from sites that were deemed best for the purpose of my research.

We selected the required human bone and tooth samples based on two criteria: 1) their usefulness for stable isotopic analysis; and, 2) their removal would not interfere with any future MNIs. Hofman and Adair selected and identified the faunal samples that would be used. Twenty-one of the selected samples were human and four were white-tailed deer (*Odocoileus virginianus*). The human samples included twelve long bone fragments, eight teeth, and one fused cranial element (Table 6.1). White-tailed deer samples included cranial, vertebral, and appendicular elements (Table 6.1). We included the deer samples to provide a comparative baseline for the human SIRA results.

We used six visual identification methods in selecting samples to provide adequate materials for analysis. Our bone samples were selected based on type, condition, cortical content, and overall size. We chose teeth based on type, condition, completeness, and maxillary or mandibular alveoli intactness. Because individuals tend to have the same overall skeletal robusticity (Ubelaker 2008: 3), the size and superficial features of the bone and teeth were also taken into account to reduce the chance of an individual being represented more than once in the study. We also crosschecked the museum catalog numbers to reduce the chance of sample duplication.

After selecting the samples, we recorded their measurements and physical attributes for future reference. SIRA requires the destruction of the sample being analyzed, so specimen attributes must be recorded. These attributes included: basic dimensions, notable damage (taphonomic or otherwise), sex, age, and any pathology. We also photographed the specimens in high-resolution, using the TIFF standard archival format in order to preserve any minute details useful for future identification. All data recorded in this process was also added to the university's NAGPRA inventory for use in any potential requests for repatriation.

| Site | Site Number | Catalog Number | Element | Sex |
|---|---|---|---|---|
| **Human** | | | | |
| Timber Creek | 14CY32 | 2698-1 | left ulna | |
| Timber Creek | 14CY32 | 2698-2 | right radius | |
| Timber Creek | 14CY32 | 2379 | right M1 | |
| Dan Younkin | 14GE2 | 12794 | right ulna | |
| Dan Younkin | 14GE2 | 14380 | right M2 | |
| Berry | 14GE4 | 2589-1 | left tibia | |
| Berry | 14GE4 | 2589-2 | left femur | |
| Berry | 14GE4 | 2689-1 | fibula | |
| Berry | 14GE4 | 2689-2 | left fibula | |
| Berry | 14GE4 | 2342 | left M2 | |
| James Younkin | 14GE6 | n/a | ulna | |
| James Younkin | 14GE6 | 14375 | P3 | |
| James Younkin | 14GE6 | 14373 | P3 | M |
| James Younkin | 14GE6 | n/a | ulna | |
| Dixon | 14GE7 | 14477 | M2 | M |
| Dixon | 14GE7 | 11892 | M1 | |
| Dixon | 14GE7 | 12699 | frontal & ocipital | |
| Dixon | 14GE7 | n/a | M3 | |
| Dixon | 14GE7 | n/a | right radius | M |
| Dixon | 14GE7 | n/a | left humerus | F? |
| Dixon | 14GE7 | n/a | right tibia | |
| | | | | |
| **Deer** | | | | |
| Dan Younkin | 14GE2 | 14431 | right 4$^{th}$ tarsal | |
| James Younkin | 14GE6 | n/a | right tibia | |
| James Younkin | 14GE6 | n/a | right scapula | |
| Dixon | 14GE7 | n/a | cervical | |

**Table 6.1. Selected Samples for this Study**

Whenever possible, we identified both the age and sex of the human elements. We began our analysis by attempting to determine their basic age – subadult vs. adult. We completed the aging of the remains first because, prior to puberty, similarities in sexually diagnostic traits make it difficult to distinguish sex-linked features (White et al. 2012: 415). Three techniques were used to provide age estimates, including: tooth eruption patterns, dental wear, and the progress of epiphyseal closure. First, we compared mandible dental eruption patterns to White et al.'s (2012: 386) dental development chart. In this diagram, illustrations depict a correlation between

age and tooth eruption patterns among Native Americans. While this chart does not account for population or sex-based developmental variation, it provided a reasonably accurate representation for the purpose of this analysis.

Four additional sources on osteological aging techniques were also consulted: Miles (1963), Smith (1991), Ubelaker (1999), and Lovejoy (1985). The first two sources provide data that indicates the average age in which human tooth eruption occurs. Ubelaker (1999) provides a chart that shows dental development specific to Native Americans. In each case, we examined the eruption progress of the right and left third molars to determine age. Analysis results were then used to corroborate our previous findings in individual age. We determined the age of some individuals using Lovejoy's (1985) modal tooth wear pattern analysis. Lovejoy's publication provides a diagram that illustrates tooth wear and dentine exposure patterns based on the remains of a prehistoric Native American population. Tooth wear in prehistoric populations is often attributed to food processing and various other cultural practices (Molnar 1972). These teeth had been removed from their mandibles prior to my analysis, so Lovejoy's method was appropriate for determining specimen age.

Next, we attempted to sex the samples using a number of criteria, including the identification of specific morphological features when present: bone robusticity, ramal flexion, and dental dimensions. For teeth, sex can sometimes be determined based on canine and molar size (White et al. 2012: 415). For this process, mandibular canines are used because they show the greatest amount of sexual dimorphism at 7.3%, followed by those of the maxilla (Hillson 2005). Molar crown size can also be used in sexing an individual, but with less accuracy. Unfortunately, the average size difference between sexes is very small: an average of half a millimeter (White et al. 2012: 415). Such accuracy was beyond the means of the equipment

available to us. Thus, attempting to sex the samples without highly accurate equipment would have increased the likelihood of measurement error. Due to this possibility, we sexed teeth using their associated mandibles.

We chose Walker's (1994) mandible sexing technique because of its demonstrated accuracy. This qualitative scoring system determines sex based on the protuberance of the mental eminence (Figure 6.1). Hyperfeminine mandibles tend to have a minimal expression of this feature, while hypermasculine mandibles often have a maximal expression. Using Walker's criteria, we examined each of the mandibles to determine the degree of mental eminence expression. Whenever present, we also analyzed three other mandible features to increase the accuracy of sample sexing. These features included: the angulation of the posterior ramal border, the degree of gonial angle eversion, and overall rugosity. Male mandibles tend to have a maximal expression of each of these attributes, while female mandibles usually lie on the minimal end of expression (White et al. 2012: 414). After examining each of these features, we were only able to assign individual sex for two of the samples using Walker's (1994) method (Table 5).

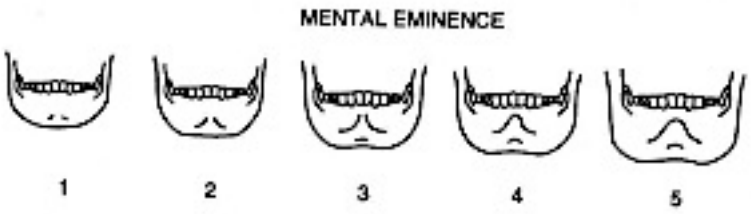


**Figure 6.1. Walker's (1994) Mandible Chart Detailing Degrees of Mental Eminence Expression**

While it would have been ideal to be able to sex the long bone samples for our analysis, this was not possible. These samples, which included a proximal end of a right radius and a distal end of a left humerus, had been sexed in the past using unknown techniques. In order to accurately determine the sex of a long-bone sample, a portion of the diaphysis or a complete specimen must be present. These elements can be used to determine sex based on their length and their overall robusticity. Bass (2005:19) states that researchers use the maximum diameter of the head of the femur and the humerus for sexual determination. Bone ossification progress can also be used, when a comparative sample of the same age is available. Osteologists consider ossification advancement methods viable because female ossification centers tend to appear sooner than those of a male. However, conducting such an analysis requires examining the ossification order of the capitulum radii and the medial epicondyle (Bass 2005: 164). Due to our criteria in sample selection, we did not have samples that were long enough, or we lacked these necessary elements.

Adair included deer elements from the burial mounds in the study for two reasons. She selected them primarily to provide a baseline for oxygen isotope analysis. Due to the variation of oxygen isotopes in meteoric and terrestrial waters, researchers can use the $\delta^{18}O$ values for these locations to determine basic mobility strategies in both humans and animals (Pollard et al. 2007:191). Adair also selected deer bone samples because they are frequently found at Central Plains Woodland sites and are considered to be a source of subsistence for prehistoric Plains populations (Bozell 2011:379). Given coevality for both subjects, one could use similarities in the $\delta^{13}C$ and $\delta^{15}N$ analysis results as a proxy to support any dietary interpretations drawn from the stable isotope analyses. Therefore, we included the deer samples for testing.

Following selection and classification, we sent the samples to Ambrose's lab at the University of Illinois at Urbana-Champaign for preparation and analysis. Due to my lack of training, the absence of appropriate lab space at the University of Kansas, and the sophistication of the preparation techniques, students in Ambrose's lab also handled sample preparation. This procedure included cleaning and chemical alteration of the samples necessary for the analysis. In each case, the sample preparer used hydrochloric acid to complete the process. Matthew Fort, a student of Ambrose's lab, carried out every step of the procedure under the supervision of the Associate Director, Kristen Hedman.

Fort removed the cortical bone and surface discoloration to prepare the samples for collagen extraction. He used a dremel to grind down the outer compact bone and scrubbed away any surface discoloration in distilled water. Once these steps were completed, the bone collagen was purified and demineralized using hydrochloric acid (HCl). Next, he soaked the samples in sodium hydroxide (NaOH) and acetic acid ($CH_3COOH$) to prepare them for their analysis. Bathing the samples in these chemicals removed any additional contaminants that may have persisted. Following the purification process, the samples were dried, weighed, and made ready for the mass spectrometer (Ambrose 1990).

Fort then ran the samples, in a continuous flow mode, using a Carlo Erba NC 2500 Elemental Analyzer coupled to a Finnigan MAT 252 isotope ratio mass spectrometer. The Finnegan MAT 252 mass spectrometer "permits automated analyses of sub-milligram samples of organic matter, and carbonates, and analysis of incremental growth structures" (Fort, personal communication September 10, 2012). Throughout this procedure, each fragment was heated until it combusted, allowing for the release of $CO_2$ and $N_2$ gasses. As the gasses were released, the machine detected the various stable isotopes present in the samples. Data from the results

was then converted through the Conflo II interface into intelligible information that can be interpreted by a trained technician, and an archaeologist.

Following the analysis, the computer compared the Schultz samples to the universal laboratory standards. The lab used Vienna Pee Dee Belemnite (VPDB) as the standard for the stable carbon isotopes. AIR-$N_2$ was used as the standard for the stable nitrogen isotopes. These comparisons provided the delta notations for both the carbon and nitrogen elements. Because the differences between the tested samples and the international standards are so small, they are expressed in the parts per thousand (‰) format. Conversion of this data into delta notations provided the numbers necessary for later statistical and visual interpretation.

The combined results of the $\delta^{13}C_{apatite}$, $\delta^{13}C_{collagen}$, and $\delta^{15}N$ analyses allowed for a comparison of the stable isotopes that reflect the individual's overall diet to those obtained through dietary protein. To review, isotopes representing overall carbon intake are found in bone apatite, while those that are indicative of carbon dietary protein intake are found in bone collagen (Tykot 2006: 135). Nitrogen isotope intake values only appear in bone collagen. Although testing for these elements requires only a one-gram sample of bone, it was necessary to select a large enough sample that would allow for the removal of material that would ensure a pure sample. Bones can become contaminated by taphonomic processes and post-excavation bone exposure and handling. Any impurities must be removed prior to analysis to ensure accurate results.

Adair requested that the laboratory suggest at least twenty samples for radiocarbon dating once we received the isotope results. She selected twelve samples for accelerator mass spectrometer (AMS) dating based on sample condition. Sample selection was based on their completeness and their $\delta^{13}C_{apatite}$, $\delta^{13}C_{collagen}$, and $\delta^{15}N$ values. During the SIRA, seven of the

samples had been reduced to sizes that were considered too small for AMS dating. The AMS dating technique requires at least two to three grams of well-preserved bone for collagen extraction (Wang, personal communication September 24, 2012). Due to this destruction, they were limited to the number of samples they could suggest. Fort and Hedman examined the $\delta^{13}C_{apatite}$ and $\delta^{13}C_{collagen}$ values in order to determine which of the individuals' values reflected a diet that may have been heavily dependent on $C_4$ plants. The quantity of the $\delta^{15}N$ values was also examined to determine which individuals were high or low in their nitrogen isotope intake. Using their suggestions based on this information, Adair selected the appropriate samples for dating.

Once Adair had selected the samples for AMS dating, she sent them to Hong Wang at the Illinois State Geological Survey for the dating procedure. Wang cleaned the bone fragments using the same dremel grinding and scrubbing techniques used to prepare the materials prior to the stable isotope analyses. He purified and demineralized the bone collagen using hydrochloric (HCl) acid. The samples were soaked in sodium hydroxide (NaOH) and acetic acid ($CH_3COOH$) to remove any additional contaminants. Finally, Wang extracted the bone collagen, using the Longin (1971) method. This collagen-extraction method involves the conversion of bone protein elements to a gelatin, allowing for the removal of any remaining contaminants (Brown et al. 1988). These important steps ensured that samples would be free of contaminants following their extraction.

Once extracted, the collagen was loaded into the machine and combusted. This transformation allowed the accelerator mass spectrometer (AMS) to detect and count the $^{14}C$ atoms directly. The use of this dating technique allows for a smaller sample size and a more accurate reading than the traditional method (Renfrew and Bahn 2004: 143). The increased

accuracy and decreased sample size is possible due to the heightened sensitivity of the newer machines. As the data was processed, it was sent directly to a computer and converted into an intelligible format. After receiving the dates, Adair calibrated them using the CALIB 6.1 14C Calibration Program. In doing so, the radiocarbon dates were converted from the radiocarbon years before present (RCYBP) format to those of the Gregorian calendar.

I included data from previous stable isotope analyses to provide a larger sample and comparative numbers for this study. The first source of supplemental material was Robert Conner's (2001) thesis. In this work, he discusses the results of a stable carbon isotope analysis of human bone samples from 34 burial sites in Kansas, which included nine samples from mounds that Floyd Schultz excavated. The Schultz information was useful for both synchronic and diachronic isotopic value comparisons to determine variation in diet over time. I also used additional data from the appendix to Tieszen et al.'s (1997) paper. This source included stable isotopic ratios obtained from several animal species known to be sources of subsistence for many Central Plains groups. If the individuals from the Schultz mounds had consumed these animals, it could have altered their carbon and nitrogen signatures and given them higher $\delta^{13}C$ ratios, which may have differed had they not. Such isotopic variations can be misinterpreted as an increased dependency on $C_4$ plants when the animal data is overlooked. Therefore, their inclusion for comparison is important.

Prior to performing a statistical analysis of the current data, I plotted the isotope values on a traditional XYT axis. Doing so allowed for a visual assessment of the extent to which carbon and nitrogen sources contributed to an individual's diet. It also provided me with a basic indicator of the number of dietary clusters present within the sample population as the representative points began to group. I plotted the $\delta^{15}N$ values vertically and the $\delta^{13}C$ values

horizontally. The results indicated that there were at least two dietary patterns present in the sample population. A statistical analysis would be necessary in order to confirm any patterns within these graphs and to provide results with greater accuracy.

**Statistical Analysis**

Past similar statistical analyses of stable isotope data used only a bivariate carbon model for diet reconstruction. These models failed to discriminate between $C_4$ from plant and animal protein sources effectively (Froehle et al. 2011). Their inaccuracies were due to the use of only $\delta^{13}C_{apatite}$ and $\delta^{13}C_{collagen}$ values to determine the role that specific nutritional sources played in an individual's diet. The $\delta^{15}N$ values, which would more accurately help determine the role of animals in subsistence, were neglected. Each of these values must be considered in interpreting an individual's diet. As was previously mentioned, $\delta^{13}C_{apatite}$ values can be used to determine an individual's long-term carbon intake (Tykot 2006: 135). Carbon values obtained from bone collagen are only representative of those obtained through dietary protein. $\delta^{15}N$ values are important as they can attest to the role that legumes, and terrestrial and marine animals played in individual diet. Further details concerning these values appear in Chapter 1.

Recently, a group of researchers began to take into consideration the importance of the $\delta^{15}N$ values. Froehle et al. (2012) first used a multivariate model for paleodiet reconstruction. Their work allowed for the inclusion of the $\delta^{15}N$ values, which provided the researchers with a more accurate representation of their subject's diet. This model also provided a statistical basis for "distinguishing between food sources with similar isotopic signatures" (Froehle et al. 2012). Based on the results and the increase in accuracy that their model provided, I chose to apply it to my analysis of the Schultz data, hoping that it may resolve some dietary ambiguities.

Following the methods discussed in Froehle et al. (2012), I employed several cluster analyses using the Statistical Package for Social Sciences 20.0 for Mac (SPSS). These procedures place individuals with similar isotopic values into groups, much like the typological classification systems used in archaeology. I used both agglomerative hierarchical and *k*-means clustering in order to determine the greatest abundance of natural clusters in the Schultz dataset. As per Froehle et al. (2012), I limited the analyses based on the assumption that the samples would separate into a minimum of one diet group and a maximum of six groups. In the former position, there are no dietary differences; in the latter, every combination of diet and protein "end-members" are represented. Each of the dietary variations would be tested until the agglomerative hierarchical and *k*-means analyses indicated the optimal number of clusters in the Schultz data.

I began the statistical testing with the hierarchical cluster analysis. This technique places individuals into larger and larger groups, using "decreasingly stringent criteria for within-group homogeneity" (Froehle et al. 2011). I applied Ward's method, along with the squared Euclidean Distance, to examine differences and similarities among the cases. Ward's method uses an analysis of variance approach to examine cluster distances. It evaluates cluster affiliation by "calculating the total sum of squared deviations from the mean of a cluster. The criterion for fusion is that it should produce the smallest possible increase in the error sum of squares" (Burns & Burns 2008: 557). It also allows for clusters to remain as homogenous as possible (Shennan 1997: 241). Ward's method results produce a dendrogram, in which the length of the branches indicates the amount of similarity between samples and clusters (Everitt et al. 2001). Dendrogram branches can be used to determine the number of clusters within the data. The squared Euclidean Distance technique measures the actual geometric distance between objects in

three-dimensional space and places increasingly greater weight on cases that are further apart (Burns & Burns 2008: 557). Results of these tests can be displayed in a proximity matrix and an agglomeration schedule. I compared the dendrogram results to the value variations of the agglomeration schedule to help determine the number of clusters present in the data. To confirm the results of these analyses, I conducted a One-Way Analysis of Variance (ANOVA).

Next, I performed the *k*-means cluster and Discriminant Function analyses. The *k-means* cluster analysis was conducted following the hierarchical cluster analysis because it requires the user to have a predetermined number of clusters to be tested. A *k*-means analysis clusters data based on the distance between a centroid and dataset case values (Burns & Burns 2008: 557). Cluster centroids are derived from the means of the variables. SPSS displayed the results of this analysis in terms of their: initial cluster centers, iteration history, cluster membership, final cluster centers, and the distances between the final cluster centers. Following cluster assignment, I performed a One-Way ANOVA to confirm the significance of the assignment of cases to specific clusters. The Discriminant Function Analysis "creates an equation which will minimize the possibility of misclassifying cases into their respective groups or categories" (Burns & Burns 2008: 591) and confirmed the results of the cluster analyses. Once again, the Ward Method was used to separate cases, using both the weighted and unweighted values.

The Discriminant Function Analysis produced a significant number of outputs. I focused on the outputs that provided the most important data, including: the Group Statistics, Tests of Equality of Group Means, The Pooled Within-Groups Matrices, the Log Determinants, Test Results of Box's Test of Equality of Covariance, and the Summary of Canonical Discriminant Functions. The latter includes: the Eigenvalues, Wilks' Lambda, Standardized Canonical Discriminant Function Coefficients, the Structure Matrix, the Standardized Canonical

Discriminant Function Coefficients, and the Functions at Group Centroids. The final outputs of value were the Classification Statistics, which included: the Prior Probabilities for Groups and the Classification Results (including a cross-validation). One specific output of interest was the results from the Standardized Canonical Discriminant Function Analysis, which would be plugged into the following equation to determine cluster membership:

$$D = v_1X_1+v_2X_2+v_3X_3 + a$$

Overall, I examined the analysis results for uniformity and natural placement in the data clusters. Distances from cluster centroids were taken into account, and for the *k*-means test, centroids were only accepted if they could be interpreted clearly. As per Froehle et al. (2011), selection was based on their placement along the $\delta^{13}C_{collagen}$ and $\delta^{13}C_{apatite}$ axes in comparison to regression lines produced by testing the additional animal data. From these plots, the most realistic number of clusters was determined. Consistency was sought between the three methods and the *k*-means results were compared with average $\delta^{13}C_{collagen}$, $\delta^{13}C_{apatite}$, and $\delta^{15}N$ values. Any major irregularities in the results would indicate faulty case placement within the determined number of clusters.

## Chapter Seven:

## The Results

This chapter presents the results of the analyses summarized in the previous chapter. It begins with a discussion of the outcome of our attempts to determine the age and sex of our samples. Before presenting the results of the stable isotope ratio analysis (SIRA), I discuss the degree of overall sample preservation. Next, I review the geographic variability of the results are on a site by site basis. I summarize the results of the bone collagen AMS dating and I explore the possibility of temporal variance. Finally, I discuss the results of the three statistical analyses.

### Skeletal Analysis

*Determining Age*

We found it difficult to age our specimens precisely. Individual sample size, skeletal incompleteness, disparate morphological features, and the lack of appropriate training prevented us from assigning an exact range. Bone degradation, sample availability, and specimen comingling also contributed to our inability to determine element ages. Based on epiphyseal closure, it was possible to assign a general age to some long bone specimens. We were also able to provide a general age range for teeth based on the three dental methods. These aging methods allowed us to provide an older-than range for some individuals, but we had to lump all of our samples into an "adult" category.

Dental aging methods indicated that all of our tooth samples came from adults. A comparison of the tooth eruption patterns indicated that all of the individuals were at least 18 to 21 years old. We based our age estimates on the complete eruption of the right and left third molars in each of the mandibles. Miles (1963) places third molar eruption at age eighteen, while

Smith (1991) estimates that it occurs at nineteen and White et al. (2012: 386) puts it at twenty-one. Using their observations, we determined that the individuals from the current samples were not subadults. Dental wear patterns on each of the samples varied in degree. While all of them contained wear patterns that indicated they were at least twenty to twenty-four years old, there were two that showed much more wear. The first of these, a $P_3$, had advanced tooth wear and dentin exposure consistent with individuals categorized as age 40 to 45 by Lovejoy (1985). The second tooth, a left $M_2$, showed dental wear and dentin exposure consistent with Lovejoy's characteristics of 45-55 year olds.

We based our age estimates of long bone samples on epiphyseal closure, whenever the elements were intact. In one sample, an epiphysis was intact and allowed for estimates based on skeletal fusion data from McKern and Stewart (1957). Their work indicates that nearly all long bone epiphyseal closure occurs in male individuals by the age of twenty-three. Bone fusion had occurred in the sample; thus, it belonged to an adult. The eleven remaining samples were all diaphysis elements and we could not accurately determine their age. However, given their robusticity, it seems likely that the individuals were adults when they died.

*Determining Sex*

Only three of the twenty-one individuals could be sexed with certainty (Table 6.1). Due to the lack of crania, we sexed samples using only their associated mandibles. The samples that were sexable were teeth, including a premolar and two molars. The first of these teeth was an unsided $P_3$. This tooth was extracted from an adult mandible from the James Younkin site (14GE6) that bore the Schultz catalog number 14373. Due to the absence of the associated cranium, we used three sexually specific morphological features to sex the individual. The mandible had a robust mental eminence (a four on Walker's [1994] scale), a pronounced

posterior ramal border flexure, and everted gonial angles. The combined presence of these qualitative features indicated that the individual's sex was likely male. The second tooth, an unsided $M_2$, came from a mandible from the Dixon site (14GE7), and had the Schultz catalog number 14477. The absence of the cranium also required the sole use of the mandible for sexing. A prominent mental eminence (also a four on Walker's (1994) scale), angulation of the posterior ramal border, and everted gonial angles all signify that this individual was a male. The rugose nature of the gonial angles also supports this identification. The third tooth, a right $M_1$, was removed from a reconstructed mandible from the Timber Creek site (14CY32), and was cataloged as Schultz number 2379. The specimen had a prominent mental eminence (a five on the Walker (1994) scale) and everted gonial angles. Although it had been refitted, altering some features, the angulation of the posterior ramal border could still be observed. Each of the morphological indicators suggested that the sex of the mandible was male.

Based on information on the NAGPRA inventory, two of the other samples were sexed prior to our analysis, but a reason for this determination was not provided. The first of these samples was a proximal end of a right radius, the second a distal end of a left humerus. The students indicated the sex of the former to be male, and the latter, female. Bone robusticity may have influenced a gender determination, but the sole use of this measure to determine sex is not reliable. I made an attempt to determine their sex myself, but other than robusticity, there were no sex-specific characteristics that indicated individual sex. Thus, I could not determine, with accuracy, if their conclusions were correct and I left the samples unsexed.

**Sample Preservation**

The overall preservation of the human bone samples from the Schultz collection was excellent (Table 6). In nearly all of the samples, both cortical and trabecular materials were largely intact, and taphonomic processes effects were minimal. Collagen yield ranged from 0.6% to 22.1%, with a mean of 7.9%. All but one of the samples had collagen yields above the 1% cut-off point defined by van Klinken (1999). The one sample that fell below that level was considered a marginal case; however, it was still included. The C/N ratio of the samples fell within DeNiro's (1985) acceptable range of 2.9 to 3.6, varying from 3.0 to 3.6. While samples whose ratios fall outside of that range can still be used, those that fall within are preferred as they can be compared to data of modern humans and animals. The overall carbon content (wt. % C) of the samples ranged from 11.5% to 38.9% with a mean of 28.0% and the nitrogen content (wt. % N) ranged from 3.7% to 13.8%, with a mean of 10.3%.

The bone collagen preservation of the selected deer samples from the Schultz collection was also good. Collagen yield ranged from 4.5% to 17.2%, with a mean of 10.1%. The C/N ratio had a range of 3.1 to 3.3, falling within DeNiro's range. Carbon content ranged from 29.3% to 46.3%, with a mean of 37.1%. Nitrogen content ranged from 10.7% to 17.4%, with a mean of 13.5%. Overall, based on yield percentages, bone apatite and tooth enamel preservation was also good. Human apatite and enamel yields ranged from 11.7% to 32.1% with a mean of 22.8%. The average sample carbon content (wt. % C) ranged from 0.3% to 1.8%, with a mean of 0.9%. None of the samples had to be discarded due to poor preservation.

| Site Name | Site Number | Catalog Number | Element | Sex | % Col. Yield | %Ap. Yield | C/N Ratio |
|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | |
| Timber Creek | 14CY32 | 2698-1 | left ulna | | 6.5 | 20.9 | 3.1 |
| Timber Creek | 14CY32 | 2698-2 | right radius | | 6.2 | 22.6 | 3.0 |
| Timber Creek | 14CY32 | 2379 | right M1 | | 7.0 | 22.2 | 3.1 |
| D. Younkin | 14GE2 | 12794 | right ulna | | 9.4 | 26.2 | 3.2 |
| D. Younkin | 14GE2 | 14380 | right M2 | | 22.1 | 19.5 | 3.2 |
| Berry | 14GE4 | 2589-1 | left tibia | | 2.8 | 29.8 | 3.4 |
| Berry | 14GE4 | 2589-2 | left femur | | 11.3 | 22.5 | 3.4 |
| Berry | 14GE4 | 2689-1 | fibula | | 0.6 | 32.1 | 3.6 |
| Berry | 14GE4 | 2689-2 | left fibula | | 3.8 | 23.9 | 3.3 |
| Berry | 14GE4 | 2342 | left M2 | | 12.6 | 21.8 | 3.2 |
| J. Younkin | 14GE6 | n/a | ulna | | 7.7 | 20.3 | 3.3 |
| J. Younkin | 14GE6 | 14375 | P3 | | 15.7 | 15.6 | 3.2 |
| J. Younkin | 14GE6 | 14373 | P3 | M | 5.9 | 14.8 | 3.2 |
| J. Younkin | 14GE6 | n/a | ulna | | 5.9 | 21.9 | 3.3 |
| Dixon | 14GE7 | 14477 | M2 | M | 4.1 | 19.0 | 3.1 |
| Dixon | 14GE7 | 11892 | M1 | | 6.6 | 11.7 | 3.1 |
| Dixon | 14GE7 | 12699 | frontal & occipital | | 10.5 | 28.5 | 3.2 |
| Dixon | 14GE7 | n/a | M3 | | 5.4 | 23.8 | 3.1 |
| Dixon | 14GE7 | n/a | right radius | M | 11.4 | 22.4 | 3.1 |
| Dixon | 14GE7 | n/a | left humerus | F? | 9.1 | 28.6 | 3.1 |
| Dixon | 14GE7 | n/a | right tibia | | 1.3 | 30.7 | 3.1 |
| | | | | | | | |
| **Deer** | | | | | | | |
| D. Younkin | 14GE2 | 14431 | right 4$^{th}$ tarsal | | 17.2 | 18.1 | 3.1 |
| J. Younkin | 14GE6 | n/a | right tibia | | 4.5 | 16.4 | 3.4 |
| J. Younkin | 14GE6 | n/a | right scapula | | 7.7 | 12.4 | 3.2 |
| Dixon | 14GE7 | n/a | cervical | | 11.0 | 29.1 | 3.2 |

**Table 7.1. Sample Preservation**

**Isotope Values**

All human $\delta^{13}C$ and $\delta^{15}N$ values are presented in Table 7.2 and plotted in Figure 7.1. In the table, sample values are presented by site and individual catalog numbers. Table 7.2 also contains the isotopic values for deer. These values are plotted in Figure 7.2.

| Site Name | Site Number | Catalog Number | Element | Sex | δ13C collagen | δ13C apatite | $\delta^{15}N$ |
|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | |
| Timber Creek | 14CY32 | 2698-1 | left ulna | | -9.7 | -5.2 | 12.5 |
| Timber Creek | 14CY32 | 2698-2 | right radius | | -10.8 | -4.6 | 11.5 |
| Timber Creek | 14CY32 | 2379 | right M1 | | -12.0 | -5.5 | 12.9 |
| D. Younkin | 14GE2 | 12794 | right ulna | | -19.6 | -9.4 | 7.5 |
| D. Younkin | 14GE2 | 14380 | right M2 | | -18.2 | -10.9 | 7.8 |
| Berry | 14GE4 | 2589-1 | left tibia | | -13.1 | -7.8 | 11.0 |
| Berry | 14GE4 | 2589-2 | left femur | | -10.3 | -7.3 | 11.3 |
| Berry | 14GE4 | 2689-1 | fibula | | -20.7 | -15.3 | 7.5 |
| Berry | 14GE4 | 2689-2 | left fibula | | -18.4 | -12.9 | 7.7 |
| Berry | 14GE4 | 2342 | left M2 | | -11.0 | -9.1 | 10.6 |
| J. Younkin | 14GE6 | n/a | ulna | | -18.4 | -10.8 | 9.1 |
| J. Younkin | 14GE6 | 14375 | P3 | | -10.8 | -4.7 | 10.0 |
| J. Younkin | 14GE6 | 14373 | P3 | M | -19.7 | -8.7 | 6.1 |
| J. Younkin | 14GE6 | n/a | ulna | | -19.6 | -10.9 | 5.2 |
| Dixon | 14GE7 | 14477 | M2 | M | -14.1 | -4.1 | 9.3 |
| Dixon | 14GE7 | 11892 | M1 | | -10.8 | -3.2 | 9.8 |
| Dixon | 14GE7 | 12699 | frontal & occipital | | -11.3 | -6.0 | 10.3 |
| Dixon | 14GE7 | n/a | M3 | | -10.8 | -3.4 | 10.1 |
| Dixon | 14GE7 | n/a | right radius | M | -11.7 | -5.3 | 9.3 |
| Dixon | 14GE7 | n/a | left humerus | F? | -11.5 | -6.4 | 10.0 |
| Dixon | 14GE7 | n/a | right tibia | | -14.7 | -7.0 | 9.4 |
| **Deer** | | | | | | | |
| D. Younkin | 14GE2 | 14431 | right $4^{th}$ tarsal | | -20.4 | -6.4 | 3.5 |
| J. Younkin | 14GE6 | n/a | right tibia | | -19.0 | -7.1 | 4.5 |
| J. Younkin | 14GE6 | n/a | right scapula | | -19.3 | -8.5 | 3.6 |
| Dixon | 14GE7 | n/a | cervical | | -21.0 | -11.0 | 4.4 |

**Table 7.2. Stable Isotope Values**

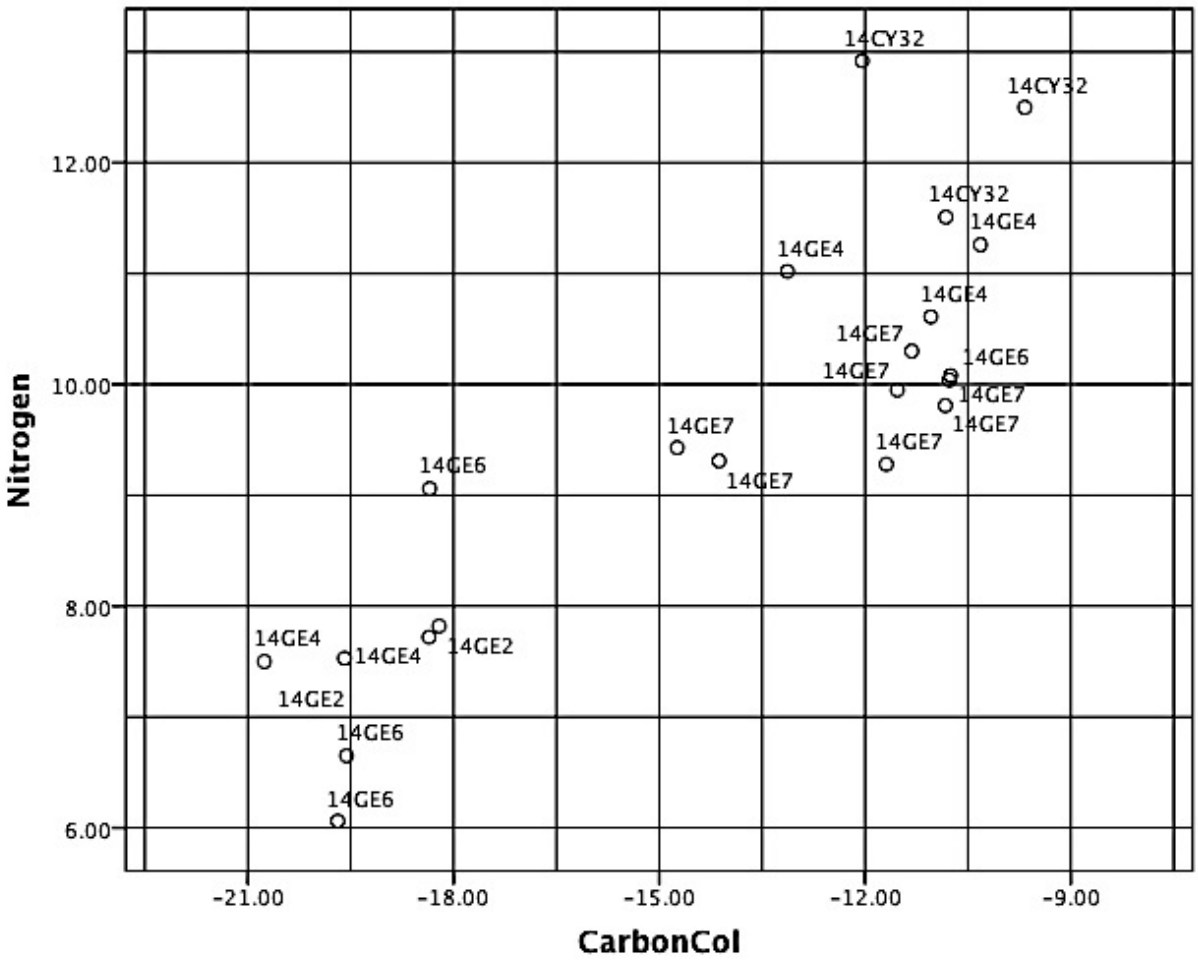


**Figure 7.1. Plot of Human Collagen Carbon and Nitrogen Values**

Human $\delta^{13}C$ values of the bone collagen ranged from -20.8‰ to -9.7‰, with a mean of -14.2‰. Bone apatite $\delta^{13}C$ values ranged from -15.3‰ to -4.6‰. The mean apatite value was -8.38‰. Tooth enamel $\delta^{13}C$ values ranged from -10.9‰ to -3.2‰, and had a mean of -6.2‰. The human $\Delta^{13}C_{ap\text{-}col}$ values ranged from 1.9‰ to 11.0‰, with a mean of 6.6‰. Tooth values spanned from 1.9‰ to 11.0‰ (mean = 7.2‰), while long bone ranges stretched from 3.0‰ to 14.0‰. The mean of the latter samples was 7.3‰. One specimen, Schultz #2342, had a $\Delta^{13}C_{ap\text{-}col}$ value less than 3.0‰, while another sample, Schultz #2589-2, fell within the 3.0-4.0‰ range. The remaining samples all held values that were greater than 4.0‰. The complete $\Delta^{13}C_{ap\text{-}col}$ values can be found in Table 7.3.

Deer $\delta^{13}C$ collagen values ranged from -20.9‰ to -19.0‰ with a mean of -20.0‰. Their bone apatite values ranged from -11.0‰ to -6.4‰ and had a mean of -8.2‰. The variation between the human and deer $\delta^{13}C$ collagen values was .2‰ on the low end and 9.3‰ on the high end. The mean variation was 5.7‰. Bone apatite $\delta^{13}C$ variation ranged from 3.2‰ to 4.3‰, with a mean difference of .7‰. Overall, the four deer sample values were more uniform than those of the 21 humans. Deer $\Delta^{13}C_{ap\text{-}col}$ value variation spanned from 8.2‰ to 14.0‰, with a mean of 10.7‰. All of the samples held values that were greater than 4.0‰. These values are presented in Table 7.2.

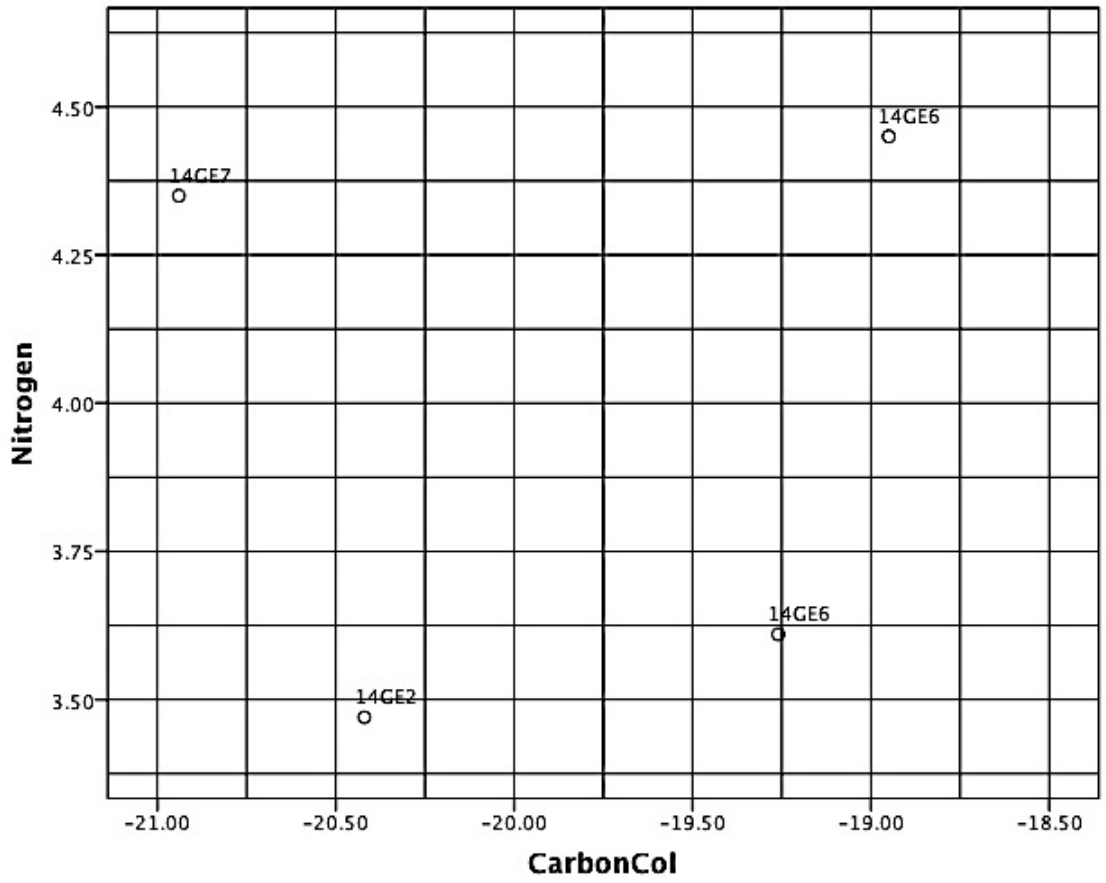


**Figure 7.2. Plot of Deer Collagen Carbon and Nitrogen Values**

Overall, there was some variation in the human to deer $\delta^{15}N$ values. The range of the human collagen $\delta^{15}N$ values spanned from 5.2‰ to 12.9‰, with a mean of 9.5‰. Deer $\delta^{15}N$ values ranged from 3.5‰ to 4.5‰, with a mean of 4.0‰. Human to deer $\delta^{15}N$ value differences ranged from 1.7‰ to 8.5‰. The mean variance of the human and deer samples was 5.5‰. A comparison of these values illustrates the difference in $\delta^{15}N$ ratios between herbivores and omnivores.

| Site Name | Site Number | Catalog Number | Element | $\Delta^{13}C_{ap\text{-}col}$ | Site Name | Site Number | Catalog Number | Element | $\Delta^{13}C_{ap\text{-}col}$ |
|---|---|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | | | |
| Timber Creek | 14CY32 | 2698-1 | l. ulna | 4.5 | J. Younkin | 14GE6 | n/a | ulna | 5.2 |
| Timber Creek | 14CY32 | 2698-2 | r. radius | 6.2 | Dixon | 14GE7 | 14477 | M2 | 10.1 |
| Timber Creek | 14CY32 | 2379 | r. M1 | 6.5 | Dixon | 14GE7 | 11892 | M1 | 7.6 |
| D. Younkin | 14GE2 | 12794 | r. ulna | 10.2 | Dixon | 14GE7 | 12699 | frontal & occipital | 5.3 |
| D. Younkin | 14GE2 | 14380 | r. M2 | 7.3 | Dixon | 14GE7 | n/a | M3 | 7.4 |
| Berry | 14GE4 | 2589-1 | l. tibia | 5.3 | Dixon | 14GE7 | n/a | rt. radius | 6.4 |
| Berry | 14GE4 | 2589-2 | l. femur | 3.0 | Dixon | 14GE7 | n/a | l. humerus | 5.2 |
| Berry | 14GE4 | 2689-1 | fibula | 5.4 | Dixon | 14GE7 | n/a | r. tibia | 7.7 |
| Berry | 14GE4 | 2689-2 | l fibula | 5.4 | | | | | |
| | | | | | **Deer** | | | | |
| Berry | 14GE4 | 2342 | l. M2 | 1.9 | D. Younkin | 14GE2 | 14431 | r. 4th tarsal | 14.0 |
| J. Younkin | 14GE6 | n/a | ulna | 7.6 | J. Younkin | 14GE6 | n/a | r. tibia | 8.0 |
| J. Younkin | 14GE6 | 14375 | P3 | 6.1 | J. Younkin | 14GE6 | n/a | r. scapula | 10.8 |
| J. Younkin | 14GE6 | 14373 | P3 | 11.0 | Dixon | 14GE7 | n/a | cervical | 9.9 |

**Table 7.3. $\Delta^{13}C_{ap\text{-}col}$ Values**

## Geographical Variability

| Site | Sample Material | Isotope Values Range | Sample Average | Sample Standard Deviation |
|---|---|---|---|---|
| **14GE2 (n=2)** | | | | |
| | collagen | -19.6‰ to -18.2‰ | -18.9‰ | 1.0‰ |
| | apatite | -9.4‰ | | |
| | enamel | -10.9‰ | | |
| **14GE4 (n=5)** | | | | |
| | collagen | -20.8‰ to -10.3‰ | -14.7‰ | 4.5‰ |
| | apatite | -15.3‰ to -7.3‰ | -10.8‰ | 3.4‰ |
| | enamel | -9.1‰ | | |
| **14GE6 (n=4)** | | | | |
| | collagen | -19.7‰ to -10.8‰ | -17.1‰ | 4.3‰ |
| | apatite | -10.9‰ to -10.8‰ | -10.8‰ | 0.1‰ |
| | enamel | -8.7‰ to -4.7‰ | -6.7‰ | 2.8‰ |
| **14GE7 (n=7)** | | | | |
| | collagen | -14.7‰ to -10.8‰ | -12.1‰ | 1.6‰ |
| | apatite | -7.0‰ to -5.3‰ | -6.2‰ | 0.7‰ |
| | enamel | -4.1‰ to -3.2‰ | 3.6‰ | 0.5‰ |
| **14CY32 (n=3)** | | | | |
| | collagen | -12.0‰ to -9.7‰ | -10.8‰ | 1.2‰ |
| | apatite | -5.2‰ to -4.6‰ | -4.92‰ | 0.4‰ |
| | enamel | -5.5‰ | | |

**Table 7.4. Stable Isotope Ranges presented by Site**

### The Dan Younkin Site (14GE2)

The Dan Younkin site had the second smallest range in human $\delta^{13}C$ values of all of the sites. The two $\delta^{13}C_{col}$ analyses revealed a range of -19.6‰ to -18.2‰ remaining in samples, with a mean of -18.9‰. The $\delta^{13}C_{ap}$ value was -9.4‰ and the tooth enamel value was -10.9‰. The $\Delta^{13}C_{ap\text{-}col}$ variance spanned from 7.3‰ to 10.2‰ and had a mean of 8.7‰. Values for the $\delta^{15}N$ analysis ranged from 7.5‰ to 7.8‰ (mean = 7.7‰). The carbon to nitrogen ratio had a mean of 3.2 and had a range of 3.1 to 3.2. $\delta^{13}C_{col}$ ranges indicate a more uniform diet for the individuals from this site. A deer tarsal had a $\delta^{13}C_{col}$ value of -20.4‰. The $\delta^{13}C_{ap}$ value was -6.4‰. The $\Delta^{13}C_{ap\text{-}col}$ variation was 14.0‰. The results of a $\delta^{15}N$ analysis indicated a 3.5‰ residual. The C:N ratio was 3.1.

**The Berry Site (14GE4)**

The five human $\delta^{13}C_{col}$ values at the Berry site had the widest span of all of the sites. They ranged from -20.8‰ to -10.3‰, with a mean of -14.7‰. The $\delta^{13}C_{ap}$ values spanned from -15.3‰ to -7.3‰, with a mean of -10.8‰. The results of the $\Delta^{13}C_{ap\text{-}col}$ analysis show a variance of 1.9‰ to 5.4‰. The mean of their values was 4.2‰. Collagen $\delta^{15}N$ values ranged from 7.5‰ to 11.3‰ and had a mean of 9.5‰. Carbon to nitrogen ratios stretched from 3.2 to 3.6 and had a mean of 3.4. Only one individual (Schultz # 2689-1) at the Berry site had $\delta^{13}C$ values that fell outside their standard deviations.

**The James Younkin Site (14GE6)**

The James Younkin site had the second largest span in human $\delta^{13}C$ and $\delta^{15}N$ values of all of the selected sites. Values from the four human $\delta^{13}C_{col}$ analyses ranged from -19.6‰ to -18.4‰ (mean = -17.1‰). The $\delta^{13}C_{ap}$ values spanned from -10.9‰ to -4.7‰, with a mean of -8.8‰. The $\Delta^{13}C_{ap\text{-}col}$ variance ranged from 6.1‰ to 11.0‰ and had a mean of 8.3‰. $\delta^{15}N$ values stretched from 5.2‰ to 10.0‰. Their mean was 8.3‰. The carbon to nitrogen ratio had a mean of 3.2 and ranged from 3.0 to 3.3. The human $\Delta^{13}C_{ap\text{-}col}$ variance appeared higher than normal at this site. Deer samples had $\delta^{13}C_{col}$ values that ranged from -19.3‰ to -19.0‰, with a mean of -19.1‰. The $\delta^{13}C_{ap}$ values had a range of -8.5‰ to -7.1‰ (mean = -7.8‰). A difference of 8.2‰ to 10.8‰ exists for the $\Delta^{13}C_{ap\text{-}col}$ values. $\delta^{15}N$ values spanned from 3.6‰ to 4.5‰ (mean = 4.0‰). The C:N ratio ranged from 3.1 to 3.3, with a mean of 3.3. $\delta^{13}C$ values were more uniform for deer than those of their human coinhabitants.

**The Dixon Site (14GE7)**

The Dixon site had the smallest range of human $\delta^{13}C$ values of all of the chosen sites. The seven human $\delta^{13}C_{col}$ values ranged from -14.7‰ to -10.8‰ and had a mean of -12.1‰.

Values of the $\delta^{13}C_{ap}$ analysis spanned from -7.0‰ to -3.2‰ (mean = -5.1‰). The $\Delta^{13}C_{ap\text{-}col}$ varied from 5.2‰ to 10.1‰, with a mean deviation of 7.1‰. The $\delta^{15}N$ values stretched from 9.3‰ to 10.3‰ and had a mean of 9.7‰. The carbon to nitrogen ratio ranged from 3.1 to 3.2, with a mean of 3.1. The sole deer element from the Dixon site had a $\delta^{13}C_{col}$ value of -20.9‰. Its $\delta^{13}C_{ap}$ value was -11.0‰. $\Delta^{13}C_{ap\text{-}col}$ analysis results had a difference of 9.9‰. The $\delta^{15}N$ value was 4.4‰ and the C:N ratio was 3.2. The human $\delta^{15}N$ value range was highest at this site, as were all of the deer isotopic values.

**The Timber Creek Site (14CY32)**

The Timber Creek site had the second lowest range of $\delta^{15}N$ values of all of the chosen sites. Three human bone samples from the Timber Creek site had a $\delta^{13}C_{col}$ range of -12.0‰ to -9.7‰, with a mean of -10.8‰. The $\delta^{13}C_{ap}$ values spanned from -5.5‰ to -4.6‰ (mean = -5.1‰). Values from the $\delta^{15}N$ analysis ranged from 11.5‰ to 12.9‰ and had a mean of 12.3‰. Carbon to nitrogen ratios had a span of 3.0 to 3.1, with a mean of 3.1. All values indicate a fairly uniform diet for the individual's buried at this site.

**Results of AMS (Accelerator Mass Spectrometry) Radiocarbon Dating**

Radiocarbon dates obtained from eleven human samples provided a 2σ temporal range of cal. 350 B.C. to A.D. 380. A date obtained from a deer tarsal produced a 2σ range of cal. A.D. 1440-1615. The earliest temporal range (cal. 350-90 B.C.) came from an individual from Mound 3 at the Dan Younkin site (14GE2). The sample with the most recent date had a temporal range of cal. A.D. 240-380. This individual was buried in Mound 2 at the Berry site (14GE4). The full AMS results are presented in temporal order by site in Table 7.5.

| Site Name | Site Number | Catalog Number | Element | Sex | δ13C collagen | δ13C apatite & enamel | $\delta^{15}N$ | 2σ range |
|---|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | | |
| D. Younkin | 14GE2 | 12794 | right ulna | | -19.6 | -9.4 | 7.5 | 349-95BC |
| Berry | 14GE4 | 2689-2 | left fibula | | -18.4 | -13.0 | 7.7 | AD 128-312 |
| Berry | 14GE4 | 2589-2 | left femur | | -10.3 | -7.3 | 11.3 | AD 131-318 |
| Berry | 14GE4 | 2589-1 | left tibia | | -13.1 | -7.8 | 11.0 | AD 235-376 |
| J. Younkin | 14GE6 | n/a | ulna | | -18.4 | -10.8 | 9.1 | AD 34-133 |
| J. Younkin | 14GE6 | 14375 | P3 | | -10.8 | -4.7 | 10.0 | AD 85-221 |
| Dixon | 14GE7 | 14477 | M2 | M | -14.1 | -4.1 | 9.3 | AD 29-128 |
| Dixon | 14GE7 | 11892 | M1 | | -10.8 | -3.2 | 9.8 | AD 54-212 |
| Dixon | 14GE7 | 12699 | frontal & occipital | | -11.3 | -6.0 | 10.3 | AD 54-212 |
| Timber Creek | 14CY32 | 2698-2 | right radius | | -10.8 | -4.6 | 11.5 | AD 127-252 |
| Timber Creek | 14CY32 | 2698-1 | left ulna | | -9.7 | -5.2 | 12.5 | AD 230-346 |
| **Deer** | | | | | | | | |
| D. Younkin | 14GE2 | 14431 | right 4$^{th}$ tarsal | | -20.4 | -6.4 | 3.5 | AD 1440-1615 |

**Table 7.5. Results of AMS Radiocarbon Dating**

## Temporal Variability

I placed the human bone samples into chronological order by site (Table 7.5). Where there are two or more samples from each site, there seems to be a pattern indicating an increased enrichment in the samples' $\delta^{13}C_{collagen}$, $\delta^{13}C_{apatite}$, and $\delta^{15}N$ values over time. For example, the $\delta^{13}C_{collagen}$ values from the Berry site increase from -18.4‰ to -13.1‰ and the $\delta^{15}N$ values show an overall increase from 7.7‰ to 11.0‰. In each instance where there is an increase in $\delta^{13}C_{collagen}$ values, there is also an increase in $\delta^{15}N$ values. Thus, the two values may be related. At the same time, there are individuals within those temporal ranges whose stable isotope values are higher than those on the more recent end of the temporal ranges from the Berry and Dixon sites. In the individual from the Dixon site (11892), the change in the $\delta^{13}C_{collagen}$ values do not appear to correspond with the $\delta^{15}N$ values as tightly as they do with the individual from the Berry site.

**Results of Statistical Analyses**

A hierarchical cluster analysis suggested that there were two clusters present in the sample population. These groups can be divided into individuals who had low $\delta^{13}C_{collagen}$, $\delta^{13}C_{apatite}$, and $\delta^{15}N$ values (n=7), and those whose values were higher (n=14). I reached a two-cluster conclusion based on the agglomeration schedule (Table 7.6), and the Ward's linkage dendrogram (Fig. 7.3) resulting from the analysis. Changes in the agglomeration schedule coefficients indicated that the last significant value variation occurs at two clusters. Beyond two groups, the minimal value variation produced by additional clustering makes it difficult to distinguish between cases. The dendrogram also showed that there were two clear clusters present in the sample population. The clusters appeared at a distance from one another of approximately 2.8‰.

A One-Way ANOVA confirmed the results of the hierarchical cluster analysis (Table 7.7). The between groups mean square of the $\delta^{13}C_{collagen}$ values was 268.8, and it had an F value of 157.0. The $\delta^{13}C_{apatite}$ values' between groups mean square was 144.5, with an F value of 40.6. The between groups mean square of the $\delta^{15}N$ values was 44.7, with an F value of 38.1. The One-Way ANOVA descriptive results (Table 7.8) also support a two-cluster outcome. In each case, the standard deviations from the means fell within an acceptable level, as did the degree of standard errors.

| Stage | Cluster Combined | | Coefficients | Stage Cluster First Appears | | Next Stage |
|---|---|---|---|---|---|---|
| | Cluster 1 | Cluster 2 | | Cluster 1 | Cluster 2 | |
| 1 | 11 | 12 | .1 | 0 | 0 | 13 |
| 2 | 14 | 16 | .2 | 0 | 0 | 7 |
| 3 | 9 | 18 | 1.0 | 0 | 0 | 12 |
| 4 | 6 | 13 | 1.9 | 0 | 0 | 7 |
| 5 | 8 | 17 | 3.2 | 0 | 0 | 8 |
| 6 | 19 | 21 | 4.5 | 0 | 0 | 11 |
| 7 | 6 | 14 | 6.1 | 4 | 2 | 13 |
| 8 | 7 | 8 | 8.1 | 0 | 5 | 15 |
| 9 | 3 | 5 | 10.2 | 0 | 0 | 17 |
| 10 | 4 | 15 | 13.1 | 0 | 0 | 14 |
| 11 | 19 | 20 | 16.0 | 6 | 0 | 16 |
| 12 | 2 | 9 | 19.4 | 0 | 3 | 15 |
| 13 | 6 | 11 | 26.7 | 7 | 1 | 16 |
| 14 | 4 | 10 | 34.6 | 10 | 0 | 19 |
| 15 | 2 | 7 | 46.0 | 12 | 8 | 18 |
| 16 | 6 | 19 | 57.8 | 13 | 11 | 17 |
| 17 | 3 | 6 | 75.7 | 9 | 16 | 19 |
| 18 | 1 | 2 | 97.9 | 0 | 15 | 20 |
| 19 | 3 | 4 | 122.4 | 17 | 14 | 20 |
| 20 | 1 | 3 | 580.5 | 18 | 19 | 0 |

**Table 7.6. Agglomeration Schedule**

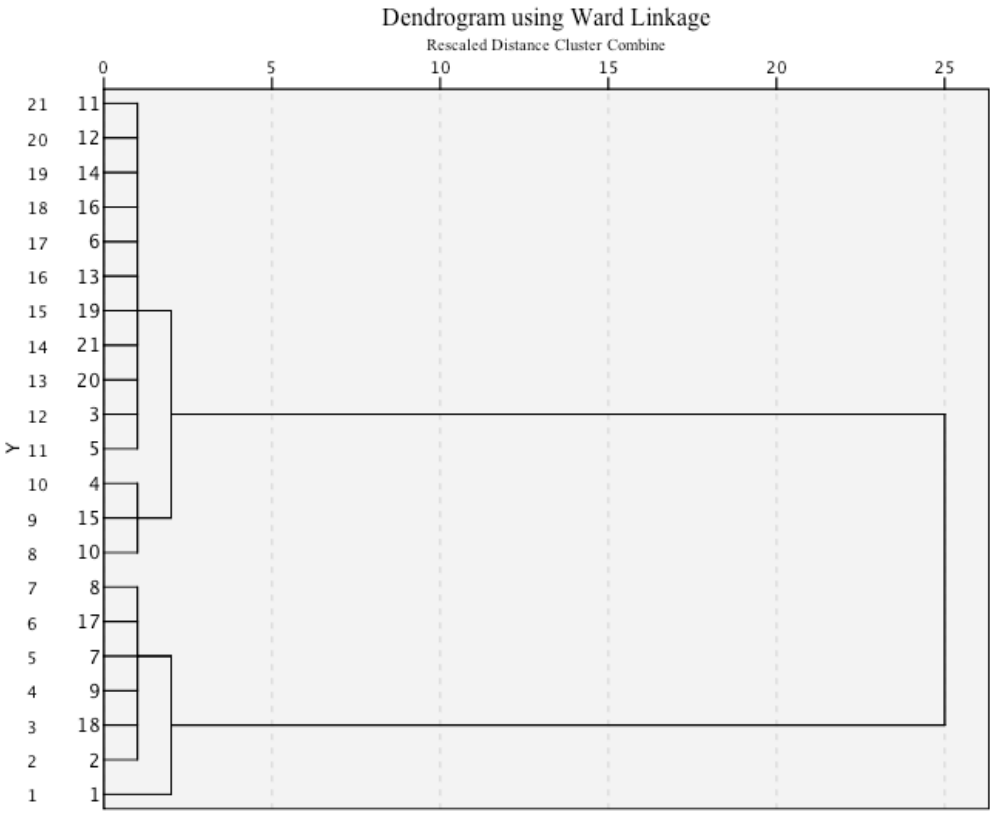


**Figure 7.3. 2 Hierarchical Cluster Analysis: 2 Cluster Dendrogram**

| | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| CarbonCol | Between Groups | 268.8 | 1 | 268.838 | 157.0 | .000 |
| | Within Groups | 32.5 | 19 | 1.712 | | |
| | Total | 301.4 | 20 | | | |
| CarbonAp | Between Groups | 144.5 | 1 | 144.523 | 40.6 | .000 |
| | Within Groups | 67.6 | 19 | 3.557 | | |
| | Total | 212.1 | 20 | | | |
| Nitrogen | Between Groups | 44.7 | 1 | 44.723 | 38.1 | .000 |
| | Within Groups | 22.3 | 19 | 1.173 | | |
| | Total | 67.0 | 20 | | | |

**Table 7.7. One-Way ANOVA Results**

| | | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower Bound | Upper Bound | | |
| Carbon Col. | 1 | 7 | -19.2 | .9 | .4 | -20.1 | -18.4 | -20.8 | -18.2 |
| | 2 | 14 | -11.6 | 1.4 | .4 | -12.5 | -10.8 | -14.7 | -9.7 |
| | Total | 21 | -14.2 | 3.9 | .8 | -15.9 | -12.4 | -20.8 | -9.7 |
| Carbon Ap. | 1 | 7 | -11.3 | 2.2 | .8 | -13.3 | -9.2 | -15.3 | -8.7 |
| | 2 | 14 | -5.7 | 1.7 | . 5 | -6.7 | -4.7 | -9.1 | -3.2 |
| | Total | 21 | -7.5 | 3.3 | .7 | -9.0 | -6.1 | -15.3 | -3.2 |
| Nitrogen | 1 | 7 | 7.5 | .9 | .4 | 6.6 | 8.4 | 6.1 | 9.1 |
| | 2 | 14 | 10.6 | 1.1 | .3 | 9.9 | 11.2 | 9.3 | 12.9 |
| | Total | 21 | 9.5 | 1.8 | .4 | 8.7 | 10.4 | 6.1 | 12.9 |

**Table 7.8. Descriptives**

A k-means cluster analysis confirmed the optimal number of clusters. The results indicated that the hierarchical cluster analysis was correct in predicting two groups. Initial cluster centers for group one appeared at -20.8‰ for the $\delta^{13}C_{collagen}$ values, -15.3‰ for the $\delta^{13}C_{apatite}$ values, and 7.5‰ for the $\delta^{15}N$ values. The initial cluster centers for group two were the -9.7‰ for the $\delta^{13}C_{collagen}$ values, -5.2‰ for the $\delta^{13}C_{apatite}$ values, and 12.5‰ for the $\delta^{15}N$ values. The number of clusters being tested limited the iteration history to two runs. In the first iteration, the change in the cluster center for group one was limited to 4.4‰, while the change for the second group was 2.8‰. The minimum distance between the initial centers was 15.8‰.

The final cluster centers for group one appeared at -19.2‰ for the $\delta^{13}C_{collagen}$ values, -11.3‰ for the $\delta^{13}C_{apatite}$ values, and 7.5‰ for the $\delta^{15}N$ values. For group two, the final cluster centers were at -11.6‰ for the $\delta^{13}C_{collagen}$ values, -5.7‰ for the $\delta^{13}C_{apatite}$ values, and 10.6‰ for the $\delta^{15}N$ values. In each case, a higher $\delta^{13}C$ value appeared to coincide with a higher $\delta^{15}N$ value. Plot value distances within cluster one range from 1.0‰ to 4.3‰. Distances in group two ranged from .5‰ to 3.5‰.

Results of a Discriminant Function Analysis also confirmed the necessity for only two clusters. In this analysis, SPSS used all of the values to determine the outcome. Once again, the Ward method was used to separate cases, using both weighted and unweighted values (Table 7.9). In group one, the mean of the $\delta^{13}C_{collagen}$ values was approximately -19.2‰, with a standard deviation of .9‰. The mean of the $\delta^{13}C_{apatite}$ values was approximately -11.3‰, with a standard deviation of 2.2‰. The mean of the $\delta^{15}N$ values was approximately 7.5‰, with a standard deviation of .9‰. For group two, the mean of the $\delta^{13}C_{collagen}$ values was approximately -11.6‰, with a standard deviation of 1.5‰. The mean of the $\delta^{13}C_{apatite}$ values was -5.7‰, with a standard deviation of 1.7‰. Finally, the mean of the $\delta^{15}N$ values was approximately 10.6‰, with a standard deviation of 1.1‰.

| Ward Method | | Mean | Std. Deviation | Valid N (listwise) | |
|---|---|---|---|---|---|
| | | | | Unweighted | Weighted |
| 1 | CarbonCol | -19.2 | .95 | 7 | 7.0 |
| | CarbonAp | -11.3 | 2.2 | 7 | 7.0 |
| | Nitrogen | 7.5 | .9 | 7 | 7.0 |
| 2 | CarbonCol | -11.6 | 1.4 | 14 | 14.0 |
| | CarbonAp | -5.7 | 1.7 | 14 | 14.0 |
| | Nitrogen | 10.6 | 1.1 | 14 | 14.0 |
| Total | CarbonCol | -14.2 | 3.9 | 21 | 21.0 |
| | CarbonAp | -7.5 | 3.3 | 21 | 21.0 |
| | Nitrogen | 9.5 | 1.8 | 21 | 21.0 |

**Table 7.9. Group Statistics**

The results of the overall totals in the Discriminant Function Analysis were also presented in the output. The total mean for the $\delta^{13}C_{collagen}$ values was approximately -14.2‰, with a standard deviation of 3.9‰. The total mean of the $\delta^{13}C_{apatite}$ values was -7.6‰, with a standard deviation of 3.3‰. The total mean of the $\delta^{15}N$ values was approximately 9.5‰, with a

standard deviation of 1.8‰. Based on the mean differences between the $\delta^{13}C_{collagen}$ values and the $\delta^{15}N$ values, it appears that they were good discriminators.

In the Test of Equality of Group means (Table 7.10), the $\delta^{13}C_{collagen}$ variables had a Wilks' Lambda value of .1 and an F value of 157.0. The Wilks' Lambda value of the $\delta^{13}C_{apatite}$ variables was .3, with an F value of 40.6. The $\delta^{15}N$ variables had a Wilks' Lambda value of .3 and an F value of 38.1. Based on the variation in the Wilks' Lambda and F values, it appears that the groups were well separated. In each of the variable sets, the degrees of freedom were 1 and 19 respectively. In this test, the $\delta^{13}C_{collagen}$ variables had the largest F values, while those of the $\delta^{13}C_{apatite}$ and the $\delta^{15}N$ variables had F values with little separation (2.5). The Pooled Within-Groups Matrices (Table 7.11) indicated little to no correlation between the $\delta^{13}C_{collagen}$, $\delta^{13}C_{apatite}$, and $\delta^{15}N$ variables. For the $\delta^{13}C_{collagen}$ variables, the correlative values are .2 for $\delta^{13}C_{apatite}$, and .4 for $\delta^{15}N$. The $\delta^{13}C_{apatite}$ to $\delta^{15}N$ correlative values are extremely low at -.2.

| | Wilks' Lambda | F | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| CarbonCol | .108 | 157.0 | 1 | 19 | .000 |
| CarbonAp | .319 | 40.6 | 1 | 19 | .000 |
| Nitrogen | .333 | 38.1 | 1 | 19 | .000 |

**Table 7.10. Tests of Equality of Group Means**

| | | CarbonCol | CarbonAp | Nitrogen |
|---|---|---|---|---|
| Correlation | CarbonCol | 1.0 | .2 | .4 |
| | CarbonAp | .2 | 1.0 | -.2 |
| | Nitrogen | .4 | -.2 | 1.0 |

**Table 7.11. Pooled Within-Groups Matrices**

The log determinants and the Box's M test also support the existence of two clusters (Tables 7.12 & 7.13). The log determinant of group one was .7, while that of group two was 1.8.

The pooled within-groups had a log determinant of 1.6. Given that the log determinant values are fairly close to one another, it appears that the groups are different. The value of the Box's M was low at approximately 3.6, with an F value of .5. The significance value was .8.

| Ward Method | Rank | Log Determinant |
|---|---|---|
| 1 | 3 | .7 |
| 2 | 3 | 1.8 |
| Pooled within-groups | 3 | 1.6 |

The ranks and natural logarithms of determinants printed are those of the group covariance matrices.

**Table 7.12. Log Determinants**

| | | |
|---|---|---|
| Box's M | | 3.6 |
| F | Approx. | .5 |
| | df1 | 6 |
| | df2 | 914.7 |
| | Sig. | .8 |

Tests null hypothesis of equal population covariance matrices.

**Table 7.13. Test Results**

Additional techniques within the Discriminant Function Analysis also supported my conclusion that there were two groups. The first of these, a Canonical Discriminant Analysis produced an Eigenvalue of 9.4 (Table 7.14). The percent of Variance was 100, as was the Cumulative percentage. The Canonical Correlation was .95, which suggests that the two-cluster model explains 90.4% of the grouping variable variation. A Wilks' Lambda (Table 7.15) test also supported this model with a Chi-square value of 40.9 and a significance value less than .001. The actual Wilks' Lambda score of .1 indicated that only 9.7% of the grouping variable variation was left unexplained when using this model.

| Function | Eigenvalue | % of Variance | Cumulative % | Canonical Correlation |
|---|---|---|---|---|
| 1 | 9.4[a] | 100.0 | 100.0 | .95 |

a. First 1 canonical discriminant functions were used in the analysis.

**Table 7.14. Eigenvalues**

| Test of Function(s) | Wilks' Lambda | Chi-square | df | Sig. |
|---|---|---|---|---|
| 1 | .097 | 40.9 | 3 | .000 |

**Table 7.15. Wilks' Lambda**

Results of a Standardized Canonical Discriminant Function Analysis displayed varying coefficient values for each of the isotopic variables (Table 7.16). This test indicated that the most important predictor was the $\delta^{13}C_{collagen}$ values, which fell at . 8. The $\delta^{13}C_{apatite}$ values appeared next at .4, and the $\delta^{15}N$ values came in last at .2. The results of the Standardized Canonical Discriminant Function Analysis were supported by the results of a Structure Matrix. The correlative values for the function and the isotopic variables were as follows: .9 for the $\delta^{13}C_{collagen}$ variable, .5 for the $\delta^{13}C_{apatite}$ variable, and .5 for the $\delta^{15}N$ variable.

| | Function |
|---|---|
| | 1 |
| CarbonCol | . 8 |
| CarbonAp | .4 |
| Nitrogen | .2 |

**Table 7.16. Standardized Canonical Discriminant Function Coefficients**

The Canonical Discriminant Function Analysis also presented a set of unstandardized coefficients to create a discriminant function. For the $\delta^{13}C_{collagen}$ variables, the coefficient was .6.

For the $\delta^{13}C_{apatite}$ values, the coefficient was .2. The value for the $\delta^{15}N$ variables was .2 and the constant was 8.3. This produces the function:

$$D = (.6 \times \delta^{13}C_{collagen}) + (.2 \times \delta^{13}C_{apatite}) + (.2 \times \delta^{15}N) + 8.3$$

The group centroids appear at -4.1 for group one and 2.1 for group two.

Classification statistics are also presented to support the two-group model. A Ward Method analysis found that the prior probabilities for the seven cases in group one were .3. The prior probabilities for the fourteen cases in group two were .7. Two graphs were also presented for a visual confirmation of the results of the group separation provided by the Canonical Discriminant Function (Fig. 7.4). These figures appear to support the two-group model. Finally, the results of the classification phase indicated that 100% of the original two-group memberships were correctly identified. Prediction appeared correct and all of the cases were tested. Results of a cross-validation test of the classification phase indicated that there was 100% accuracy in the original predicted group membership (Table 7.17).

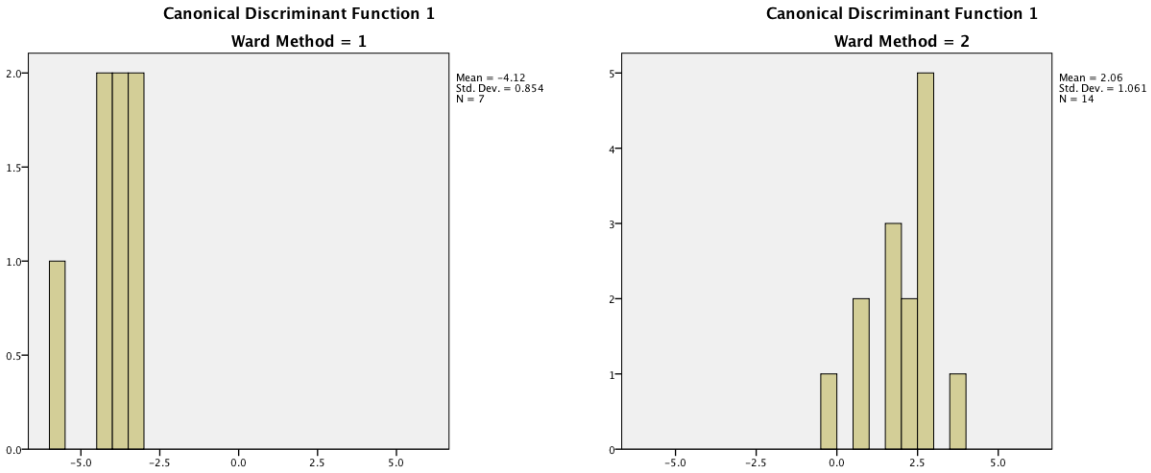


**Figure 7.4. Canonical Discriminant Function Graphs**

| | | Ward Method | Predicted Group Membership | | Total |
|---|---|---|---|---|---|
| | | | 1 | 2 | |
| Original | Count | 1 | 7 | 0 | 7 |
| | | 2 | 0 | 14 | 14 |
| | % | 1 | 100.0 | .0 | 100.0 |
| | | 2 | .0 | 100.0 | 100.0 |
| Cross-validated[b] | Count | 1 | 7 | 0 | 7 |
| | | 2 | 0 | 14 | 14 |
| | % | 1 | 100.0 | .0 | 100.0 |
| | | 2 | .0 | 100.0 | 100.0 |

a. 100.0% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 100.0% of cross-validated grouped cases correctly classified.

**Table 7.17. Classification Results[a,c]**

## Chapter Eight:

## Discussion and Conclusion

This study examined the $\delta^{13}C_{collagen}$, $\delta^{13}C_{apatite}$, and $\delta^{15}N$ values of twenty-one individuals from five burial sites. The results were surprising, as I expected more uniform values. Instead of being lumped into the expected homogenous grouping, the values fell into two visually and statistically confirmed clusters. In cluster one, low $\delta^{13}C$ and $\delta^{15}N$ values prevailed, but they were comparable to coeval samples from other sites. Cluster two held $\delta^{13}C$ and $\delta^{15}N$ values that fall more in line with individuals from the Late Woodland period and beyond. Thus, interpretation of the stable isotope values would not be as definite and simple as I had originally expected.

### Explaining Stable Isotope Differences

### Diet

*Cluster 1*

| Site Name | Site Number | Catalog Number | Element | Sex | δ13C collagen | δ13C apatite | $\delta^{15}N$ |
|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | |
| D. Younkin | 14GE2 | 12794 | right ulna | | -19.6 | -9.4 | 7.5 |
| D. Younkin | 14GE2 | 14380 | right M2 | | -18.2 | -10.9 | 7.8 |
| Berry | 14GE4 | 2689-1 | fibula | | -20.8 | -15.3 | 7.5 |
| Berry | 14GE4 | 2689-2 | left fibula | | -18.4 | -13.0 | 7.7 |
| J. Younkin | 14GE6 | n/a | ulna | | -18.4 | -10.8 | 9.1 |
| J. Younkin | 14GE6 | 14373 | P3 | M | -19.7 | -8.7 | 6.1 |
| J. Younkin | 14GE6 | n/a | ulna | | -19.6 | -10.9 | 5.2 |
| **Deer** | | | | | | | |
| D. Younkin | 14GE2 | 14431 | right 4th tarsal | | -20.4 | -6.4 | 3.5 |
| J. Younkin | 14GE6 | n/a | right tibia | | -19.0 | -7.1 | 4.5 |
| J. Younkin | 14GE6 | n/a | right scapula | | -19.3 | -8.5 | 3.6 |

**Table 8.1. Cluster 1 Values**

Low $\delta^{13}C$ and $\delta^{15}N$ isotope ratios define the formation of the first cluster. This group contains seven individuals from three sites (Table 8.1). Their $\delta^{13}C$ values range from -20.8‰ to -18.2‰, with a mean of -19.2‰. The group's $\delta^{15}N$ values spread from 5.2‰ to 9.1‰, and have an average of 7.3‰. Based on our analysis, each of the samples represent adults. The only sexed sample (#14373) came from the James Younkin site, which we determined to be male.

Cluster one members may have relied partially upon animals that are browsers or mixed feeders. These animals tend to follow steady subsistence strategies. Ungulates such as pronghorn antelope, white-tailed deer, and mule deer fall into the browser category, while elk tend to be mixed feeders (Robbins et al. 1995). Browsers subside mainly on $C_3$ plants, such as bushes, shrubs, and forbs, and have low $\delta^{13}C$ and $\delta^{15}N$ values (Vogel 1978). Mixed feeders such as elk tend to have higher isotope ratios than browsers (Stewart et al. 2003). Deer samples culled from the Schultz mounds have $\delta^{13}C$ and $\delta^{15}N$ values that fall in line with those reported by Tieszen et al. (1997:250) from other Central Plains states. Given the 3-4‰ enrichment that occurs in $\delta^{15}N$ values between trophic levels, Cluster 1 individuals may have consumed local deer, based on a comparison of their $\delta^{15}N$ values (Table 21).

Support for the dietary conclusion regarding deer, along with other animals appears in the archaeological literature (Bozell and Winfrey 1994; Bozell et al. 2011:363; Johnson and Johnson 1998:203-225; O'Brien 1984:51; Wedel 1986:91-93). All of these sources point to the high degree to which deer, elk, bison, pronghorn, and birds played in Middle Woodland subsistence strategies. Bozell et al. (2011:363) postulate that there was a great emphasis on deer and bison for food throughout this time in the Great Plains. However, the authors indicate that these people supported large animal sources with a variety of other animals and plants. In their syntheses of the Woodland period, Johnson and Johnson (1998:203-225), as well as O'Brien (1984:51) have

also commented on the high usage of these fauna in Great Plains Middle Woodland diets. Based on the reliability of these sources, these creatures played a substantial dietary role in the subsistence patterns of people from this period of time.

Additional support for the focused use of these animals is found in the archaeological record. Archaeologists have recovered their remains in sites throughout the Central Plains, including four coeval neighboring habitation sites. Deer made up the bulk of large herbivores found (31.7%) at the Elliott site, while these animals, along with elk, comprised the bulk of the identifiable fauna from the Ashland Bottoms site (Sorrell 1974; O'Brien et al. 1979). In Cultural Horizon's 1 and 2 (cal. A.D. 2- 456) at the Macy site, deer and bison were the most represented among identifiable animal remains (Banks et al. 2001; Benison et al. 2000:79-83). Each of these authors also reported the presence of food-processing tools and hearths at these sites, suggesting the likely consumption of these animals. Such frequent recovery of these species indicates the regularity that site occupants ate them. However, prior to making any definitive statements regarding subsistence, these remains should be reexamined for any cultural modification evidence, such as marks of butchery. While it is likely that at least some of these remains can be associated with human subsistence patterns, none of the authors of the aforementioned publications comments on any use alteration. Thus, the degree to which humans consumed these animals remains unknown.

Faunal consumption was likely supplemented by plant sources. Their addition provided these people with a wider range of nutritional sources. Based on the archaeological record, people from the Middle Woodland period made use of both wild plants and cultigens (Tables 3.1 & 3.2). While the individuals in Cluster 1 consumed some $C_4$ and CAM plants, such as amaranths (*Amaranthus spp.*), crabgrass (*Digitaria sanguinalis*), echinochloa (*Echinochloa*

*spp.*), and prickly-pear cacti (*Opuntia spp.*), a majority of their plant intake consisted of $C_3$ species. The highest $\%C_4$ collagen value among these individuals was 11.3%, while the group mean was 4.6%. The highest $\%C_4$ apatite value is 46.1%, while the group average was approximately 20.5%. Thus, their $C_4$ plant intake was low. Instead, they probably consumed some of the native and cultivated $C_3$ botanicals.

$\delta^{13}C$ ratio comparisons and their recovery from a nearby excavation may indicate $C_3$ plant consumption. However, this assumption is only based on the potential affiliation of the Elliott site with the Schultz Focus burials. Based on O'Brien and Park-Mandel's (2007) account, they recovered several of these plants remains from the site, including docks (*Rumex spp.*) and goosefoot (*Chenopodium spp.*). Given the previously stated known $\delta^{13}C$ range for $C_3$ plants, and the $\delta^{13}C$ values for the Cluster 1 individuals, it is probable that they were consuming these plants. Their presence at other regional archaeological sites dating to the same time period may attest to their use. Mary Adair (1996:105) reports the presence of goosefoot and docks, along with domesticated squash (*Cucurbita pepo var. ovifera*), grapes (*Vitis spp.*), marshelder (*Iva annua*), sunflowers (*Helianthus annuus*), and pawpaws (*Asimina triloba*) at two Kansas City Hopewell sites – Trowbridge (14WY1) and Quarry Creek (14LV401). While their presence at those sites does not indicate specifically that these people used them, their concomitant consumption increases their usability for dietary inference. However, further samples and analyses are needed to confirm their use with certainty.

*Cluster 2*

High $\delta^{13}C$ and $\delta^{15}N$ signatures characterize Cluster 2's content. This group includes fourteen persons from four sites (Table 8.2). Their $\delta^{15}N$ values range from 9.3‰ to 12.9‰, with a mean of 10.6‰. The mean of their $\delta^{13}C$ values is -11.6‰, and they vary between -14.1‰ and -9.7‰. We classified all of the individuals as adults, but we were only able to sex two of the samples (males) with certainty. We sexed a third individual as a possible female, although it was not definitive without a more complete skeleton.

| Site Name | Site Number | Catalog Number | Element | Sex | δ13C collagen | δ13C apatite | $\delta^{15}N$ |
|---|---|---|---|---|---|---|---|
| **Human** | | | | | | | |
| Timber Creek | 14CY32 | 2698-1 | left ulna | | -9.7 | -5.2 | 12.5 |
| Timber Creek | 14CY32 | 2698-2 | right radius | | -10.8 | -4.6 | 11.5 |
| Timber Creek | 14CY32 | 2379 | right M1 | | -12.0 | -5.5 | 12.9 |
| Berry | 14GE4 | 2589-1 | left tibia | | -13.1 | -7.8 | 11.0 |
| Berry | 14GE4 | 2589-2 | left femur | | -10.3 | -7.3 | 11.3 |
| Berry | 14GE4 | 2342 | left M2 | | -11.0 | -9.1 | 10.6 |
| J. Younkin | 14GE6 | 14375 | P3 | | -10.8 | -4.7 | 10.0 |
| Dixon | 14GE7 | 14477 | M2 | M | -14.1 | -4.1 | 9.3 |
| Dixon | 14GE7 | 11892 | M1 | | -10.8 | -3.2 | 9.8 |
| Dixon | 14GE7 | 12699 | frontal & occipital | | -11.3 | -6.0 | 10.3 |
| Dixon | 14GE7 | n/a | M3 | | -10.8 | -3.4 | 10.1 |
| Dixon | 14GE7 | n/a | right radius | M | -11.7 | -5.3 | 9.3 |
| Dixon | 14GE7 | n/a | left humerus | F? | -11.5 | -6.4 | 10.0 |
| Dixon | 14GE7 | n/a | right tibia | | -14.7 | -7.0 | 9.4 |
| **Deer** | | | | | | | |
| Dixon | 14GE7 | n/a | cervical | | -20.9 | -11.0 | 4.4 |

**Table 8.2. Cluster 2 Values**

The individuals represented in Cluster two relied partially upon fauna that were grazers, and possibly, carnivores. These animals tend to migrate where food and water sources are accessible. Among the principal grazers that dominate the Central Plains archaeological record is bison (*Bison bison*) (Smith 1991:50). These creatures tend to stay in familiar areas – near water and rich food sources (Haukos 1994). Throughout the year, bison prefer to consume the most nutritious forage available, focusing on $C_3$ grasses in the fall and spring and $C_4$ grasses in

the summer (Bamforth 1988:79). Based on their diet, they have higher stable isotope values than browsers (Stewart et al. 2003). Carnivores tend to stay in areas where food and water sources are abundant. Known species from the Great Plains included: wolves, coyotes, large cats, bears (omnivores), and smaller species (Bozell et al. 2011:359). Given their subsistence preferences, they likely aggregated near water sources to prey upon animals in search of water. Based on the $\delta^{13}C$ and $\delta^{15}N$ values of both carnivores and herbivores reported by Bozell et al. (1997:334-337), Cluster 2 individuals may have consumed some of these creatures. This observation is based on a comparison of the cluster's stable isotope values and the trophic level changes that occur between consumers and the consumed. However, we need more direct evidence to evaluate this possibility.

Support for the use of these animals is found in the archaeological record and literature (Bozell and Winfrey 1994; Bozell et al. 2011:363; Johnson and Johnson 1998:203-225; O'Brien 1984:51; Wedel 1986:91-93). Archaeologists have recovered their remains throughout the Great Plains and also in nearby sites. Sorrell (1974) reports that bison represented the second largest amount of identifiable faunal remains at the Elliott site; predator remains were minimal. In Cultural Horizons 1 and 2 (cal. A.D. 2 - 456) at the Macy site, bison comprised the majority of the faunal remains, while small predator bones were few (Banks et al. 2007). Given the high degree of bison representation at these sites, it is likely the inhabitants were consuming them. The presence of hearths and cooking tools at these sites also suggests animal sustenance use (Sorrell 1974; Parks 1978:47; Banks et al. 2007). Gregg (2001:434, 439), Johnson and Johnson (1998:203-225), and O'Brien (1984:51) suggest these animals played a pivotal role in Middle Woodland Great Plains subsistence patterns. Thus, when the archaeological literature and site

data are combined, they support the interpretation that the Schultz mounds individuals were consuming these animals.

Based on the $\delta^{13}C$ and $\delta^{15}N$ ratios of the Cluster 2 individuals, they were supplementing their diet with $C_4$ and CAM plants. Their use may also be supported by their recovery from the nearby archaeological record. O'Brien and Parks-Mandel (2007) indicate the presence of $C_4$ plants, including: amaranths (*Amaranthus spp.*), crabgrass (*Digitaria sanguinalis*), and echinochloa (*Echinochloa spp.*), along with several others. Adair (1996:105) also reports the use of $C_4$ plants at several Kansas City Hopewell sites – Trowbridge, Quarry Creek, and Young. Prickly-pear cacti (*Opuntia spp.*) and limited quantities of maize (*Zea mays*) may have also contributed to their diets. While their presence in the nearby archaeological record does not prove that Cluster 2 individuals consumed these plants specifically, it certainly suggests their use. However, further evidence is needed to address this problem.

Additional support for $C_4$ plant intake may lie in the $\%C_4$ apatite and collagen measurements of Cluster 2. Given the high group percentages, consumption of these plants seems likely. The $\%C_4$ bone apatite measurements had a mean of 65.8%, with a range from 43.2% to 82.4%. The group %C4 bone collagen values ranged from 34.4% to 68.2%, with a mean of 55.2%. Apart from $C_4$ and CAM plants, they were likely eating some $C_3$ plants. This conclusion is reasonable considering the $C_3$ pathway use by a majority of the cultigens recovered from Middle Woodland archaeological sites.

**Paleopathology**

*Cluster 1*

Apart from sustenance intake, individual biological health may explain the isotope values of Cluster 1 members. When an individual becomes ill, suffers trauma, acquires a disease, or suffers dietary stress, it often has permanent detrimental effects on the general health of the body and skeleton. Dietary stress can also aversely affect the general health. When such ailments persist, bones and teeth can record evidence of their manifestation (Rothschild & Martin 1993:5). These markers appear in forms such as Harris lines, reactive bone, and lesions (White et al. 2012:430-450). In paleopathological studies, their presence offers clues to an individual's overall health. Two such studies exist for the Schultz sites: Phenice's 1969 skeletal analysis, and a more recent evaluation of three sites by Sean Dougherty (2012a-d). Together, they may provide some insight into stable isotope values from Cluster 1.

Of the three sites represented in this cluster, the James Younkin site has three members. We categorized each of these individuals as adults, but successfully sexed only one - #14373, which was a male. In his skeletal analysis, Phenice (1969:35-36) estimated there to be 20 individuals represented in the mound. Of these individuals, three show evidence of cranial pitting (porotic hyperostosis), which Phenice attributed to malnutrition. While this was commonly thought to be an indicator of iron-deficiency anemia, more recent evidence suggests that it is linked to hereditary anemia, $B_{12}$ deficiency, vitamin C deficiency, and loss of blood from parasitic infection (Dougherty 2012a). Thus, a general malnutrition diagnosis cannot be used to explain the stable isotope values from this site in Cluster 1. Other factors may need consideration.

Two persons from the Dan Younkin site appear in the first cluster. Samples represent each of the mounds. We were unable to sex either person and we classified both samples as adults. Dougherty (2012b) estimated the minimum number of individuals from this site to be 17. He notes that Dan Younkin individuals had higher hypoplastic enamel defect frequencies than those from the other sites (Dougherty also examined skeletal material from 14CY32 and 14GE4). The appearance of these markings suggests the group experienced biological hardships, "perhaps related to fluctuations in nutritional resource availability" (Dougherty 2012b). According to Mays (2010), these defects can only form during childhood when tooth enamel is developing. These bands record nutritional stress and disease events from ages one to seven. These defects remain on a tooth's surface for the remainder of an individual's life (Mays 2010:156). Therefore, any $\delta^{13}C$ and $\delta^{15}N$ ratio fluctuations should be recorded in each individual's tooth enamel. $\delta^{13}C_{apatite}$ ratios from the two individuals are slightly lower than most of the samples; however the variations may be due to other causes.

The Berry site also has two representatives in Cluster 1, both from Mound 2. We classified each of the individuals as adults, but we were unable to provide an age for them. Dougherty (2012c) estimated the remains to represent 24 individuals. He noted several pathologies, due to various causes, but only three teeth showed signs of linear hypoplastic enamel defects (Dougherty 2012c). The two samples' $\delta^{13}C_{collagen}$ and $\delta^{13}C_{apatite}$ ratios were among some of the lowest in the entire study. The $\%C_{4\ apatite}$ and the $\%C_{4\ collagen}$ levels of these individuals were also among the lowest. Sample #2689-1 had a 1.8% apatite reading and a very low -5.7% protein reading. However, these anomalous low readings are likely due to a low collagen yield in the sample. Sample #2689-2 also had very low $\delta^{13}C$ ratios, with normal

collagen yields. These results suggest the possibility of malnutrition in childhood; however, additional proxies are needed to support this conclusion.

*Cluster 2*

Like the individuals from Cluster 1, biological health may have also affected those from the second group. This cluster includes fourteen individuals from four sites. Group $\delta^{13}C$ and $\delta^{15}N$ values were somewhat higher than those of their Cluster 1 counterparts. Cluster 2 includes the Berry (14GE4), James Younkin (14GE6), Dixon (14GE7), and Timber Creek (14CY32) sites. The Berry and Dixon sites contained one mound, while the Timber Creek site had two. Given the high stable isotope values from these sites, pathology may not have been prevalent at these sites.

The Berry site description was included with Cluster 1. However, I should note that four individuals from this site appear in Cluster 2. All of the samples from both clusters represent Mound 2. We classified each of these samples as adult, but due to their small size, we could not sex them. Evidence suggests the presence of an endemic form of syphilis (Dougherty 2012c). Nutritional stress pathologies were low at the Berry site. Based on their high $\delta^{13}C_{apatite}$ and $\delta^{13}C_{collagen}$ values, the four individuals in Cluster 2 did not suffer any notable nutritional deficiencies.

Seven individuals represent the Dixon site in this cluster. We classified all of them as adults, and we sexed two individuals as males - # 14477 and another without a catalog number. We assigned sex to a third individual, a possible female, but this conclusion is not absolute. Phenice (1969:37) estimated the minimum number of individuals from this site to be nine. In his report, he does not discuss pathologies from the site. Either this was an oversight in the publication, or there were no individual pathological markers present in the Dixon collection.

Given the prevalence of pathology in the other Schultz sites, a reexamination of the remains may be needed to determine if any exist.

The Timber Creek site has three representatives in Cluster 2. We aged each of these individuals as adults, but we could not determine their sex. Dougherty (2012d) estimated the minimum number of individuals from Mounds 1 and 2 to be 36 and 23, respectively. He found linear hypoplasia enamel defects in two teeth from one individual in Mound 1 (Fig. 8.1). Only one tooth exhibited enamel hypoplasia in Mound 2 (Dougherty 2012d). Thus, evidence of nutritional stress was low at this site. High $\delta^{13}C_{apatite}$ values appear to support Dougherty's conclusions.

**Figure 8.1. Linear Enamel Hypoplasia on Right $I_2$ from the Timber Creek Site**

**Sex and Age**

Individual sex may also factor into the variances in the stable isotope ratios. Women may have had differential access to subsistence sources than men. Habicht-Mauche, Levendosky, and Schoeninger (1994:296) found significant variation in mean stable nitrogen ratios between males and females from Antelope Creek sites during the Plains Village period. The authors found that sex differences were more important than geographic variability and diachronic changes in diet in determining nitrogen isotope ratio variation. A statistical comparison of stable carbon isotope ratios between sexes suggested there were no significant differences in values. This may indicate differential access to protein sources between men and women. If this possibility is true, Cluster 2 individuals may contain more males than females. When the authors' Antelope Creek nitrogen values for men are compared to those from Cluster 2 of this study, they fall into the same general area. However, given our inability to sex all of our samples, I cannot confirm that individual sex played a role in defining the stable isotope ratio distribution in this study.

Individual age may have also contributed to variations in stable isotope ratios between clusters. Inability to consume certain foods or differential access to food sources due to age may possibly play a role in the distribution of stable isotope ratios. Given that we only selected samples from adults for this study, I cannot use breastfeeding practices to explain individual stable isotope value differences. Therefore, if age did play a factor, it would have been due to advanced age. Considering the commonality of antemortem tooth loss at some of the sites used for this study, it is possible that older individuals may have had difficulty chewing meat and other foods (Dougherty 2012a; Phenice 1969). If this explanation is valid, it may explain some of the low stable isotope ratios that appear in Cluster One. However, due to our inability to

determine individual age, other than "adult," I cannot use this possibility to explain the stable isotope ratio differences between the two clusters.

**Time**

Change in diet over time may have also played a role in stable isotope ratio distribution. When dated samples are placed in chronological order by site, there appears to be a general increase in the $\delta^{13}C_{collagen}$ and $\delta^{15}N$ ratios as time progresses. Results of a bivariate statistical analysis between the $\delta^{15}N$ and $\delta^{13}C$ values suggests a correlation of .86 ($p<.001$). Therefore, there may have been a slight increase in protein consumption over time. However, I cannot fully support this interpretation. Given the overlap of the $2\sigma$ date ranges and the study's small sample size, I cannot substantiate any claims regarding changes in diet over time. Due to the possibility of high or low stable isotope values occurring in any given time period, I suggest caution in making such claims without further proof. Conner (2001:117) reports $\delta^{13}C_{collagen}$ values as high as -12.2‰ as far back as the Archaic period. On the opposite end, Bender et al. (1981) reported samples ranging from -19.8‰ to -14.7‰ as late as AD 1050. Tieszen et al. (1997:329) also report $\delta^{13}C_{collagen}$ values as low as -20.9‰ from the Pataga Point site, which dates to AD 1500 – 1700. Therefore, archaeologists cannot expect chronological change to explain stable isotope variations across cultures, unless they correspond to substantial dietary changes. Other justifications are necessary.

**Social Stratification**

Based on the Schultz mound remains, social stratification cannot be used to explain stable isotope signature variances. I reached this conclusion for four reasons. The first is based on the lack of careful control in Schultz's mound excavations. As mentioned, his methods were conditioned by their time and his lack of formal training. Stratigraphic control was poor, as were

his notes, making it difficult to associate any artifacts with the dead that may suggest higher status of one individual over another. He excavated the mounds at depths of two feet at a time with picks and shovels, only stopping when he hit artifact or bone "pockets." Given that most of these mounds were no more than 45 inches in height, such resolution was not fine enough. In the two instances where mounds contained separated burial chambers, Schultz did not provide clear descriptions for them, nor did he separate these individuals from the others following their recovery. Figure 3 illustrates the clarity of the excavations. My second reason is that when Schultz did provide stratigraphic information on artifacts, there was a considerable amount of space filled with sediment, separating the skeletal remains and the cultural materials. Thus, any indication of individual social status is not clear.

Social stratification cannot explain isotopic signatures due to our poor understanding of the Schultz Focus individuals. We need to first identify these individuals before we can understand their sociopolitical organization. Eyman's (1966) Schultz Focus classification is based solely on Schultz's burial mounds. While some have suggested site affiliations (O'Brien & Parks-Mandel 2007), to date no habitation sites have been clearly associated with the mounds. Without a grasp on settlement patterns, subsistence economies, and sociopolitical organization, it is difficult to clearly define a group, much less infer social stratification. The only defining characteristics we know about these people are limited to the contents of their mounds – they buried their dead in mounds and they interacted with the Hopewell culture. Therefore, more work is needed before we can define individual social positions.

Researchers have not studied Middle Woodland groups well enough to firmly grasp many relevant aspects of their cultures. Thus, I cannot use social stratification to explain stable isotope differences in this study. According to Gregg (2001), little is known about the social and

political structures of Central Plains Woodland groups. They were semi-sedentary hunter-gatherers who incorporated horticulture to support their diet. He posits that their level of social stratification was vague, suggesting they lived among family, both nuclear and extended (Gregg 2001:440). Eyman (1966) also suggested similar social organizations. While these accounts may eventually prove true, at present, they are merely speculation. Given the lack of habitation sites associated with non-Hopewell groups and clear mound excavations, it remains difficult to define the sociopolitical organization of these groups. Therefore, archaeologists cannot simply rely on this explanation to account for stable isotope variation.

**Multiple Group Usage**

Multiple group usage of the mounds may also explain the variation in stable isotope ratios. While a single group may have used multiple mounds, it is possible that other groups may have buried their dead in the Lower Republican River basin. For example, individuals buried at the Dan Younkin site may have been from a group from within the basin area while those buried at the Timber Creek site may have been from a separate region. The Timber Creek individuals may have had more access to $C_4$ plants and $C_4$ enriched consumers in a different environment. However, based on the current evidence, I cannot confirm or deny this possibility. If burial sites are "territorial markers" as Renfrew (1973) suggests, these mounds may belong only to a local group. Additional research, such as strontium isotope analysis, may provide the evidence needed to substantiate any such claims.

**Comprehensive Interpretation**

A mixed diet explains the variation in the Schultz Focus individuals' isotope signatures. Cluster differences exist due to differential sustenance consumption, along with limited nutritional stress. While they obtained some of their $\delta^{13}C$ and $\delta^{15}N$ ratios through faunal

enrichment, these people could not have relied upon the meat from these creatures alone. According to Noli and Avery (1988), overconsumption of meat can lead to protein poisoning. The upper limit of meat protein consumption by humans is around 20-50% of their daily calories. They claim that protein poisoning would result in any degree of consumption beyond 50%. The highest recorded amount of meat consumed is around 15-25% of daily calories (Noli & Avery 1988; McClellan & Du Bois 1930; McClellan et al. 1931; Speth and Spielmann 1983). Due to this possibility, animal consumption had to be limited. While the Schultz Focus people obtained some of their $\delta^{13}C$ and $\delta^{15}N$ values through faunal enrichment, additional plant sources were necessary to acquire their isotope signatures.

Given the correlation between the study's $\delta^{15}N$ and $\delta^{13}C$ ratios, the Schultz Focus people did not obtain their signatures through plant consumption alone. A bivariate statistical analysis between the $\delta^{15}N$ and $\delta^{13}C$ values suggests a correlation of .86 ($p<.001$). Thus, the two isotope values appear to be related, indicating the importance of meat enrichment. Had the consumers acquired their $^{\delta 15}N$ values through direct plant consumption, these ratios would be much lower. Given this information, it is possible to infer dietary strategies for the Schultz individuals.

Based on evidence outlined in this work, Schultz Focus individuals practiced a mixed diet. This regimen consisted mainly of herbivore fauna, such as deer and bison. Other animals were incorporated into the mix, but their consumption cannot be spoken to due to differential preservation in the archaeological record. Such fauna include birds, mussels, and fish (Bozell & Winfrey 1994). The Schultz Focus people also consumed a variety of wild plants and cultigens. Individuals from Cluster 1 consumed deer regularly, along with $C_3$ plants and limited $C_4$ plants/$C_4$ grazing fauna. Cluster 2 individuals relied on bison and other $C_4$ grazers, while occasionally consuming deer along with $C_3$ plants and $C_3$ foragers. The archaeological record

suggests the significant use of $C_4$ plants like goosefoot and amaranths (Adair 1996:105). Maize was also present at this time, but its use was highly intermittent. They also consumed CAM (prickly-pear cactus) and $C_3$ plants, both wild and domesticated. When combined, these species provided the Schultz Focus people with a diverse and nutritious menu.

**Implications for Central Plains Prehistory**

The acquisition of new data on archaeological populations provides archaeologists with a better understanding of past populations. For the individuals in this study, we know a little bit more about their subsistence strategies based on the results of their SIRAs. These results appear to support the Middle Woodland subsistence patterns suggested by archaeologists. Based on village and campsite data, archaeologists have suggested that people from this period practiced a mixed hunting-gathering and horticulture strategy (Adair 2013). The archaeological record suggests a basic reliance on a meat-related diet, which included: bison, deer, and pronghorn, supported by some plant consumption (Bozell 2006:379-380). The results of this analysis suggest such a strategy, particularly in the high nitrogen values from the individuals in Cluster 2. Cluster 1 individuals appear to have also practiced such a strategy, but on a lesser level.

Apart from individual diet, we also know more about the temporal contexts of these people. Prior to acquiring the bone collagen dates for this study, archaeologists had proposed several other temporal affiliations for these people. Kivett (1952:134) suggested a Hopewell-Keith Focus affiliation, which placed the mounds in the Late Woodland period. Eyman (1966) suggested a temporal range of A.D. 200-600, placing the mounds in the Middle Woodland period, but slightly later than the current radiocarbon dates. To review, the bone collagen AMS radiocarbon dates obtained for this study places them in a range of cal. 350 B.C. to A.D. 380, placing the mounds in the late Early Woodland and early Middle Woodland periods. Currently, I

found these new dates helpful for making dietary inferences for the individuals in this study. In future work, they'll increase the likelihood that archaeologists will be able to affiliate habitation sites with the mounds.

On a larger scale, if these values were compared to known values from other regions, they could suggest regional differences in subsistence strategies. For example, a comparison of stable isotope values from a group that lived nearby with a different environment from that of the individuals from my study, their isotope values may vary based on the animal and plant life of that area. So far, what I have is a limited data set. I have stable isotope ratios and radiocarbon dates from individuals from a mortuary complex. Since there are no habitation sites directly associated with these remains, I can only use comparative materials from nearby coeval sites to infer individual diet. With additional data from affiliated sites, the results of this analysis could speak to: 1) adaptations to any climatic and environmental changes; 2) diffusion of economic practices from surrounding groups; 3) social stratification; and, 4) provide a quantitative estimate of food intake based on faunal and botanical remains from the archaeological record.

**Stable Isotope Reliability**

SIRA provides archaeologists with direct dietary insight into diets of past populations. Prior to its use, archaeologists had to rely upon the recovered faunal and botanical remains, iconographic evidence, and inferences from indirect evidence such as stone tools to infer diet. Following the discovery of its archaeological applications, SIRA added an additional proxy to increase the accuracy of subsistence strategy interpretation. However, this tool cannot be used alone to reach any definitive conclusions. As Schoeninger and Moore (1992) aptly stated, SIRA "does not provide a clear window to the past but, rather, permits one to look 'through the glass darkly.'" Environmental and biological complexity smudges the process's clarity, requiring the

invocation of the archaeological record to provide some transparency. As archaeologists continue to grasp its strengths and limitations, they can focus the method's aperture to sharpen its resolution.

**Future Research**

Due to the chances of equifinality in stable isotope research, new methods are needed to provide clearer conclusions. Conner (2001:121) suggests that we proactively identify as many Central Plains $C_4$ and $\delta^{13}C$ enriched food sources as possible, although this step will not alleviate the potential for equifinality. Unfortunately, many $C_3$ and $C_4$ plant species show broad overlaps in their values. Greater differences are seen between plants with differing photosynthetic pathways than with different species (John Blair, personal communication May 13, 2013). $\delta^{15}N$ values are also problematic, with an array of factors that can influence them, even at the site level. While some argue that better models may be able to compensate for these problems, we may need to turn our attention in another direction in order to improve SIRA accuracy.

One way in which we can improve its precision is by adding another proxy. This agent is nearly as direct as the bone required for SIRA, but lies a step away as secondary biomaterial. This substance is dental plaque. Several researchers have reported on the reliability of starch grain and phytolith analysis for dietary reconstructions (Henry & Piperno 2008; Hardy et al. 2009; Henry 2012). These microfossils can provide direct evidence of plant consumption. When coupled with SIRA, they can provide a clearer picture of individual diet. Christina Warinner (discussed in Honisgbaum 2012) has recently begun DNA analysis of dental plaque. In prehistory, as much as 600mg could build up on teeth throughout an individual's lifetime, providing a wealth of information. Warinner points out that in plaque, one can find plant remains, animal muscle, proteins, and bacteria. Plaque DNA may also hold answers to the

relationship between diet and disease (Honisgbuam 2012). While this technique can inform archaeologists as to what people were eating, when combined with SIRA, we may be able to infer the overall role that specific plants and animals played in individual diets. For Central Plains individuals, such as those from the Schultz mounds, when the DNA results are compared to the DNA of remains in the archaeological record, it may provide a means by which archaeologists could link burial mound individuals to habitation sites. These procedures may also expand the means by which archaeologists can continue to work with human remains to interpret the past.

Future work should also involve the attempt to determine more about the individuals from the Schultz collection. As of now, we only know them by their coarse burial contexts, but we may gain more knowledge if we can associate habitation sites with specific mounds. So far, archaeologists have suggested three nearby sites that may be related to the Schultz mounds. Their proximity to the mounds may be key in associating these sites with the burials. These sites include Macy, Elliott, and Ashland Bottoms (Banks et al. 2007, Benison et al. 2000; O'Brien & Parks-Mandel 2007). Their associations hinge on the comparative cultural materials found in both locations, along with the sites' radiocarbon dates. There is also the possibility of relationships between these mounds with the Valley Phase or other cultural variations with similar features. However, materials from all of these sites must be reexamined before any definitive conclusions are reached.

**Conclusion**

The purpose of this thesis was to build on the previous work on the Schultz collection by applying new analytical techniques and a fresh perspective. While Conner (2001) had previously conducted a SIRA on some Schultz materials, his study was limited by the use of only $\delta^{13}C$

isotope ratios. His study was also limited by the lack of absolute dates, relying only on Eyman's (1966) relative dating methods of the artifacts spread throughout the mounds. The addition of $\delta^{15}N$ values in this study allowed for a more complete interpretation of individual subsistence strategies from the Schultz sites. The inclusion of bone collagen dates provided a better temporal range for these mounds, revising Eyman's (1966) assessment of their associated chronology back in time nearly 200 years. Given these additions, we have a slightly better understanding of who these people were and when they lived.

The other purpose of this thesis was to interpret a Central Plains paleodiet without relying on the consumption of maize as an explanation for high $\delta^{13}C$ values. Too often maize is invoked to explain these high signatures while a number of $C_4$ plants and animal sources are commonly overlooked in explanation. As previously stated, maize was present during these people's time; however, its use was apparently minimal until much later. Therefore, this plant was probably not the cause of the high $\delta^{13}C$ signatures present in these individuals. The inclusion of the nitrogen values in this study, along with the interpretation of botanical and faunal materials recovered from nearby coeval sites lent some credence to this interpretation. Thus, I was able to show the use of other plants and $\delta^{13}C$ sources that can provide the same isotopic signatures.

While I was able to meet my goals with the means available to me, and additional data from Adair, there are still limitations to my thesis. Although SIRA has its advantages, it also has limitations. It cannot yet provide us with definite answers regarding paleodiet. However, its use can enhance archaeology's understanding of individual and group subsistence patterns in prehistory. But, it cannot be used appropriately without knowledge of the contexts from which the studied samples are derived. Archaeologists cannot simply pick and choose data from external environments different from those related to their sample. A mixed plains environment

plays home to a variety of plants and animals that are both endemic and specific to those regions. Plant species may demonstrate different photosynthetic pathways depending on their specific microenvironments, while animals may alter their behaviors – including their own food habits – to adapt to their specific surroundings. Therefore, extensive knowledge or adequate research of an area, with projection of possible changes from the distant past, is necessary. Future research in this area should work on enhancing the application of SIRA with some of the aforementioned techniques. Their use would provide an increased understanding of individual paleodiet. Though more research is needed to understand the Schultz Focus individuals, this study is offered as an addition to the existing literature regarding their identity.

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